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See half-page Advert. last week and next week. 2087

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BIRMINGHAM. 2530
See Advertisement last week, page 13.

Spencer-Hopwood & Kirke
PATENT BOILERS *See Page 33. March 27.* 1994
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Specification and Workmanship equal to Main Line Locomotives.
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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2207
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2276

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Worm Wheels cut up to 13 ft. diam.
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Naval Outfits a Speciality,
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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising London." —Great Eastern Road, Stratford, E. 15. 1794

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GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 88. 2584

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PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 51, March 27.

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LAND AND MARINE
YARROW BOILERS.
2277

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS Dumbarton. 2212
See Full Page Advt., page 58, March 27.

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See Advert., page 80, March 27. 3196

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Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
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Works and Offices: 120, Cornwall Street, Glasgow.
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New 300 & 500 B.HP. M.A.N.
STATIONARY DIESEL ENGINES with accessories, as delivered from the makers under Peace Treaty; also Dynamos for same. All spare parts in stock.—HICK-DIESEL OIL ENGINES LTD., 70, Queen Victoria Street, E.C 4. 2527

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Polished Zinc and Copper
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In gauges from 8—18 and sizes up to 40 by 20 in.
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For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, MANCHESTER.
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FACULTY OF ENGINEERING.

DEAN: Professor C. O. BANNISTER, M.Eng., Assoc.R.S.M., F.I.C., M.Inst.M.M.

The University awards the Degrees of B.Eng., M.Eng., D.Eng., Ph.D., and a Certificate and Diploma in Engineering.

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A prospectus of the Faculty, giving particulars of Courses and a large number of Entrance and Post-graduate Scholarships, may be had on application to the undersigned.

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Registrar. H 635

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech., London Univ. (Matric., Inter., B.Sc.), Inst. M. & Cy. E., and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours) Eng., London, Assoc.M.Inst.C.E., Chartered Civil Engineer. M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successful Students. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 2689

Draughtsmen, before

Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 758

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Millgate Building, Manchester. 2676

TENDERS.

METROPOLITAN ASYLUMS BOARD.

TO ELECTRICAL ENGINEERS.

The Board invite separate

Tenders for the Installation

of a CENTRAL BATTERY TELEPHONE SWITCHBOARD and certain ADDITIONS to the FIRE ALARM SYSTEM at the South Eastern Fever Hospital, Avonley Road, New Cross, S.E 14, in accordance with the Specification and Drawing prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawing and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Monday, 6th April, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawing has been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m., Wednesday, 22nd April, 1925.

G. A. POWELL,
Clerk to the Board. H 679

BILSTON URBAN DISTRICT COUNCIL.

NEW BRATCH WATER SCHEME—CONTRACT No. 2.

CAST-IRON PIPES.

The COUNCIL are prepared to receive

Tenders from Experienced

Pipe Founders for the SUPPLY and DELIVERY of about 1400 tons of CAST-IRON PIPES and SPECIALS, of 16-inch, 12-inch, 6-inch, 5-inch and 4-inch diameters, manufactured in accordance with the British Standard Specification.

The Specification and Form of Tender, prepared by Dr. H. LAPWORTH, M.Inst.C.E., 16, Victoria Street, Westminster, S.W.1., Engineer, may be obtained from the UNDERSIGNED upon payment of a deposit of £2. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender by the date specified and the return of the Specification.

Sealed Tenders, marked "Contract No. 2, Tender for Cast-Iron Pipes," and addressed to the UNDERSIGNED, must be delivered not later than Ten a.m., on the Sixteenth April, 1925.

The Council do not bind themselves to accept the lowest or any Tender.

JOSEPH L. ARLIDGE,
Clerk and Solicitor of the Council.
Town Hall, Bilston.
April 1, 1925. H 641

TO CONTRACTORS ONLY.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, etc., are prepared to receive separate

Tenders before Eleven

a.m., on Friday, 24th April, 1925, for the SUPPLY of MECHANICAL and ELECTRICAL ENGINEERING LABOUR during the period of Three Years in the following districts:—

Leeds.
Newcastle-on-Tyne.
Southampton.

Forms for Tender, etc. may be obtained from the CONTRACTS BRANCH, H.M. Office of Works, King Charles Street, London, S.W.1. H 676

CONDENSING PLANT AND MOTORS FOR SALE.

Sealed Tenders will be

received by the DIRECTOR OF ARMY CONTRACTS up to Eleven o'clock a.m., on the 29th April, 1925, for the following:—

TWO SETS SURFACE CONDENSING PLANT, complete with Edwards Patent Enclosed 3-cylinder Air Pump and external Condensate Pump.

TWO ELECTRIC MOTORS, each 11 HP. shunt wound 170 r.p.m., 500 volts, D.C.

TWO DRUM TYPE STARTERS for above motors.

The plant, etc., is at the Royal Arsenal, Woolwich.

Forms of Tender may be obtained on application to the DIRECTOR OF ARMY CONTRACTS (D.C. Sales), Caxton House, West Tothill Street, S.W.1. H 677

URBAN DISTRICT COUNCIL OF GOOLE.

The Goole Urban District Council invite

Tenders for Supplying, Erecting and SETTING TO WORK a STEAM PUMPING PLANT,

at their new Waterworks Borehole, at Pollington Pumping Station, near Snaith.

The Plant will consist of a Borehole Pump capable of lifting 56,000 gallons of water per hour from a depth of 200 feet below ground level, and a Force Pump for delivering the same quantity of water to Goole against a total head of 220 feet, two Boilers, an Economiser, an Overhead Traveller, an Electric Lighting Set, and all necessary auxiliary gear.

A preliminary Plan of the suggested lay-out with copies of the Conditions of Contract and Specification, can be obtained on payment of a deposit of £5 (which will be returned on receipt of a *bona fide* Tender) at the Offices of the Council, Stanhope Street, Goole, or at the Offices of the Consulting Engineer, Mr. E. J. SILCOCK, M.Inst.C.E., 35, Victoria Street, Westminster, and 10, Park Row, Leeds.

Sealed Tenders, endorsed "PUMPING ENGINES," must be addressed to the Chairman of the Gas & Water Committee, and be delivered at the Council Offices, Goole, not later than the 13th May, 1925.

The Council do not bind themselves to accept the lowest or any Tender.

J. W. PULLON,
Clerk to the Council.
Council Offices, Goole.
26th March, 1925. H 649

METROPOLITAN ASYLUMS BOARD.

TO ENGINEERS.

The Board invite separate

Tenders for:—

A. GENERAL ENGINEERING WORK, including Steam Plant, Steam and Condense Mains, Heating and H.W.S. Mains and Apparatus, Electric Motor-drives for Deep Well Engines and Laundry, etc.
B. INSTALLATION OF FOUR NEW LANCASHIRE STEAM BOILERS.
C. INSTALLATION OF NEW FUEL ECONOMISER.
D. BUILDING BRICKWORK SETTINGS for Four Boilers and Fuel Economiser.
E. INSTALLATION OF NEW LAUNDRY MACHINERY AND PLANT.
F. INSTALLATION OF ELECTRICAL GENERATING PLANT, MOTORS AND POWER WIRING, at Leavesden Mental Hospital, King's Langley, Herts; each in accordance with the Specification and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief.

The Specifications, Drawings and Forms of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Monday, 6th April, 1925, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board, in the case of (A), not later than 2.30 p.m., on Monday, 27th April, 1925, and the others (B) to (F) not later than 2.30 p.m., Wednesday, 22nd April, 1925.

G. A. POWELL,
Clerk to the Board.
H 673

APPOINTMENTS OPEN.

HUDDERSFIELD EDUCATION COMMITTEE.

HUDDERSFIELD TECHNICAL COLLEGE.

Principal: J. F. HUDSON, M.A., B.Sc.

Applications are Invited for

the POSITION of DEMONSTRATOR in the Department of Mechanical Engineering. Applicants must be specially qualified to take charge of the Advanced Mechanical Engineering Laboratories. Graduate preferred.

Salary in accordance with the Burnham Arbitration Award. Statement of Duties and Forms of Application may be obtained on receipt of a stamped addressed envelope, and must be returned not later than Saturday, 18th April, 1925.

L. G. THORNBER,
Director of Education.
Education Offices,
Huddersfield. H 680

Wanted, Assistant to Technical Managing Director of Filling Machine Manufacturers.

Must be young, pushing, good appearance and education, and A.M.I.M.E. Commencing salary about £200 or more, according to qualifications, with good prospects.—Address, H 687, Offices of ENGINEERING.

Estimator Wanted, well

trained and with sound knowledge of Reciprocating Pump work, correspondence experience preferred.—State age, experience and salary required.—Address, H 693, Offices of ENGINEERING.

Superintendent Engineer

REQUIRED for large Steam Fishing Company on the East Coast. Good Drawing Office experience essential; must possess extra Chief's ticket; Workshops experience an advantage. Only energetic capable men with initiative, who are prepared to exercise strict supervision, considered.—Apply, in first instance, stating age, qualifications, salary required, when at liberty, and forward copies of recent testimonials to BOX 1170, MORISON'S Advertising Agency, Hull. H 587

Wanted, for India, Mechanical

ENGINEER, capable of erecting steam-driven vertical air compressors, Lancashire boilers, auxiliary plant (feed pumps, etc.).—Address, with full particulars and references, and stating salary required, H 664, Offices of ENGINEERING.

Assistant Civil Engineer

REQUIRED for Consulting Civil Engineers' Office in Westminster. Must be first-rate Draughtsman and expert Surveyor and Leveller. Give full particulars of experience and state salary required.—Address, H 672, Offices of ENGINEERING.

Junior Electrical Engineer

REQUIRED in London Office of progressive firm. Graduate preferred with shop and D.O. training. Experience in power and lighting distribution advantage. Good opening for right man. Only applications from London district considered.—Address, with full particulars, giving age, experience, and salary required, H 658, Offices of ENGINEERING.

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with First-class Experience,
WANTED
by large Motor Car Manufacturing Company.

Must be able to take full responsibility for design and experimental work and control of Drawing Office staff.

Applications, which will be treated confidentially, must give full particulars of experience and state salary required.

Address—
H 686, Offices of ENGINEERING.

Experienced Designers

REQUIRED for constructional steelwork with good knowledge of calculations and details for all types of steel-framed buildings.

Candidates should have had at least three years training with a Steelwork Contractor and be capable of preparing steelwork schemes from Architect's Drawings and must have served in H.M. Forces during the War.

Applications, in writing, not later than 17th April, to "L. J.", c/o CHARLES BARKER & SONS, LTD., 31, Budge Row, E.C.4, with not more than Three copies of recent testimonials and particulars of training, experience, age, salary required, and service in Forces. H 645

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Charge of Manufacturing Engineers' Blue Print Room and Drawing Files. Must have knowledge of Rotary Blue Printing Machines and modern Photostatic and Reproduction processes, together with experience of routine filing and card indexing.—Address, stating age, experience, and salary required, H 631, Offices of ENGINEERING.

Head Draughtsman for Structural Works, Glasgow district.

Must have sound theoretical and practical experience. Age between 30 and 40. Salary about £500 or over, according to qualifications.—Address, with full particulars, H 588, Offices of ENGINEERING.

Draughtsman, Grade III,

REQUIRED for Plant Drawing Office. Candidates must have had good training and some experience of structural and plant work. Salary between 40/- and 52/- a week, plus Civil Service Bonus, giving present totals of from 69/11 to 86/4.—Apply, quoting A.56, to the SUPERINTENDENT, R.A.E., South Farnborough, Hants. H 646

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Firm of Westminster Engineers. Must have thorough knowledge and experience of works in connection with Dock, Harbour and large Public Works Contracts.—Apply, giving full particulars of age, experience and salary required, to BOX 647, c/o BROWNS, Tothill Street, Westminster, S.W.1. H 647

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Stress diagrams, Pithead gears, etc.; age under 40; good experience essential; salary £600 and quarters, for India.—Call C.W. PETTY & COMPANY (APPOINTMENT SPECIALISTS), 58, Haymarket, S.W.1. Gerrard 3412 and 3413. H 640

Draughtsman, Estimating,

thorough knowledge Sugar Machinery, REQUIRED, Glasgow; able prepare schemes, costs and plant lay-out, state full particulars, age, previous experience.—Address, H 637, Offices of ENGINEERING.

Draughtsman, Skilled in

design and lay-out of mechanical handling plants for ore and coal.

Men without actual experience need not apply.—State age, experience and salary required.—Address, H 534, Offices of ENGINEERING.

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West London require at once: (A) an ESTIMATOR experienced in taking off quantities, (B) a DRAUGHTSMAN for detail work. The work is chiefly light structural steelwork and only applications from thoroughly experienced men will be considered.—Write, stating age, salary required and experience, BOX No. 71, c/o TAYLERS, Devon House, Great Portland Street, W.1. H 661

Required, for Bristol Area,

First-class Leading DRAUGHTSMEN and JUNIORS accustomed to chemical engineering work.—Apply, by letter, giving details of experience, etc., and salary required, to THE NATIONAL SMELTING CO., LTD., Central Office, Avonmouth. H 657

Draughtsman, with all-round

experience of construction of water wheel alternators, REQUIRED by old-established firm.—State full particulars of experience and salary required.—Address, H 666, Offices of ENGINEERING.

Junior Draughtsman Wanted

for factory in S.E. London, preferably about 20 years of age, and with good general engineering experience. State age and experience.—Address, H 668, Offices of ENGINEERING.

Reciprocating Pumps.—

WANTED a Competent DRAUGHTSMAN. State age, experience and salary required.—Address, H 682, Offices of ENGINEERING.

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REQUIRED. Must be quick, neat and accurate, for detailing work on internal-combustion engines. State age, experience and salary required.—Address, H 688, Offices of ENGINEERING.

Experienced Foreman Re-

QUIRED by old-established firm, to take charge of Transformer Erecting Shop; must be accustomed to core building, fitting and assembly of windings for core type transformers. State full particulars of experience and wages required.—Address, H 561, Offices of ENGINEERING.

Pupil Required, Drawing

Office, London Refrigerating Engineers; High-class business. No premium. Nominal salary.—Address, H 669, Offices of ENGINEERING.

SITUATIONS WANTED.

Civil and Mechanical Engineer

would be glad to meet with Consultant requiring help. Wide experience on important works. Not prepared to introduce capital.—Address, H 458, Offices of ENGINEERING.

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THE REGULATION OF THE MURRAY RIVER.

(*Continued from page* 374.)

The average surface grade of the river at the part affected by the weirs decided upon is about 3 in. per mile. The weir at Blanchetown, with its lift of 10·7 ft. makes the river navigable for a distance of upwards of 50 miles. The lift adopted as regards the South Australian works averages about 10 ft. This involves the construction of eight further works between the No. 1, W.R. Randall lock and weir at Blanchetown, and the furthest point up stream where work is being undertaken by South Australia. In all cases a minimum depth of 7 ft. 6 in. of water will be available over the lock sills. The sites of these works will be noted on reference to Fig. 1, page 372, *ante* from which it will be seen that up to No. 6 the weirs will be situated in South Australia, while Nos. 7, 8 and 9 are actually in the stretch of river bounded by New South Wales on the north, and Victoria on the South. The annexed table gives the chief particulars of these works, including No. 1, completed, the locks in all cases being of the 56-ft. by 275-ft. standard adopted at Blanchetown.

These works are not being undertaken all at once, nor even in the order given, working up stream. They are being given precedence in the order in which their construction will best serve to advance irrigation projects considered jointly with navigation. For this reason the works at Nos. 3 and 5 sites were soon put in hand and are now well advanced. No. 3 will raise the water to the level of Lake Bonney, which constitutes a natural storage near an important settlement at Cobdogla, near Berri. At these two points arrangements have been made for the irrigation of over 9,000 acres. The No. 5 lock and weir will facilitate the further development of an irrigation area at Renmark, where even in 1920 over 5,000 acres were under crop, and lift pumps are proposed for further enlarging the area commanded. According to information to hand, some little while ago from the Chief Engineer for South Australia, Mr. J. G. Stewart, Nos. 4, 6, 7 and 8 had not then been put in hand. Preliminary work had been commenced at No. 2. The lock chamber and portion of the navigable pass at No. 3 had been completed, and the second cofferdam constructed. At No. 5 site temporary buildings had been put up, plant assembled and the cableway was ready, and by now the first cofferdam is well advanced. At the No. 9 site, the first cofferdam had been completed, the lock site excavated, and piles driven for foundation work, &c.

The only lock and weir of which the concrete work will rest entirely on rock is No. 3, situated not far from Kingston. The others, with the exception of Nos. 5 and 7, rest partly on rock and partly on sand, as in the case of Blanchetown, where, however, rock is only sufficiently near to the surface for part of the lock to be carried down to it. At sites Nos. 5 and 7 the sand is of great depth, and there is neither rock nor clay to which cut-off piling can be driven.

For all the works up to No. 7 crushed granite for concrete is being obtained at Mannum, 97 miles from the mouth of the Murray and about half-way between Blanchetown and the sea. At the site of No. 4 lock and weir there is, however, available locally a considerable quantity of quartz, &c. For the higher works granite from the Mannum quarry will be supplemented by quartz gravel procured from the old gold workings and brought by rail from Carisbrook, in Victoria, to Mildura, and thence conveyed in barges to the site. Local stone is available in some instances for the crib work, but will be protected with a layer of granite from Mannum. Sand of good quality is available in all cases locally.

All the above works are of similar design, adapted to the varying width of the river at the several sites, and, of course, to the substratum and to the nature of the river banks, wing walls being introduced at the ends where desirable. The No. 9 weir, in addition to serving primarily to improve navigation, will also act as a diversion weir for the Lake Victoria storage.

For the nine works listed above, all situated below Wentworth at the junction of the Murray and the Darling, no less than 62 sites were examined and 1,565 bores made before the actual positions were finally decided upon. Even then, as will be concluded from our remarks, really good foundations were not secured. It is partly for this reason that the lift has been limited to 10 ft. or so, but points which also weighed in this connection were the fact that small lifts of this nature are more easily worked, and that their adoption would reduce the risk of flooding. Again, should one work fail even with such a lift, the head on the weir next above would be about 17 ft., which would be quite as much as the structures could stand without resorting to much more costly designs.

In passing it may be mentioned No. 10 lock and weir situated at Wentworth are being constructed by New South Wales under the direction of

Fig. 19.

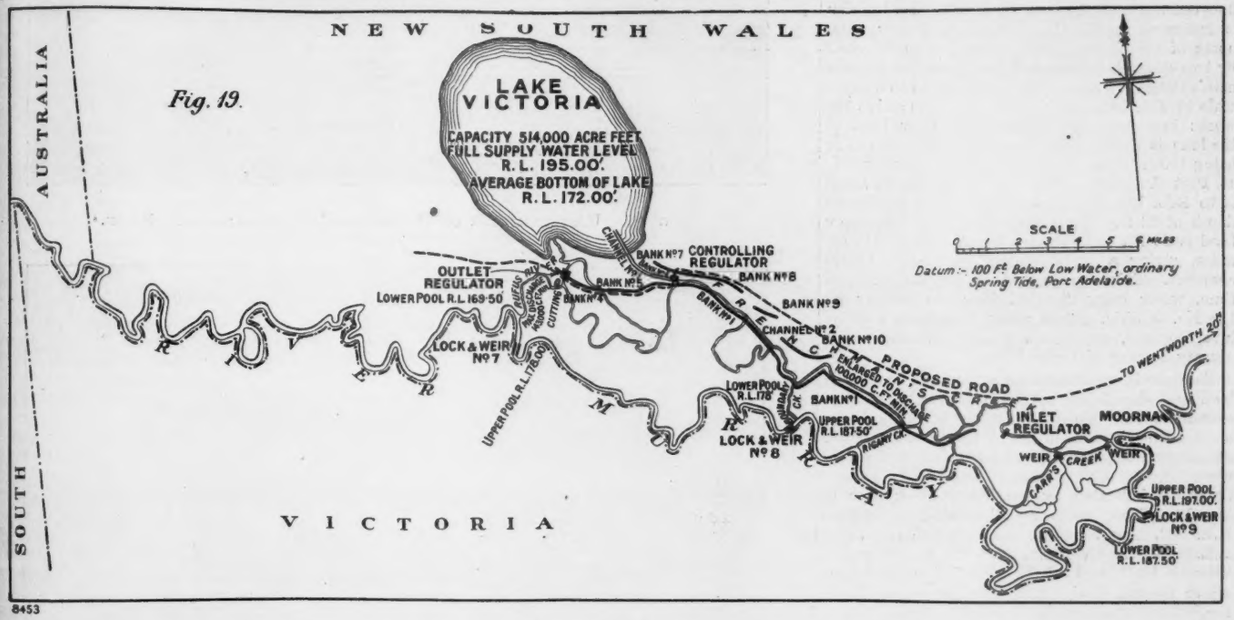


Fig. 20. Control Regulator; Frenchman's Creek.

Particulars of Locks and Weirs undertaken by South Australia.

No.	River Mileage.	Lift.	Elevation above L.W. or ordinary spring tides.		Length of Navigable Pass.	No. of sluices. 19 ft. opening 6 ft. piers.
			Down Pool.	Upper Pool.		
		Ft.			Ft.	
1	170¾	10·7	6·8	17·5	179	14
2	225¼	9·5	17·5	27·0	199	10
3	268¼	12·0	27·0	39·0	199	8
4	307¾	11·0	39·0	50·0	139	8
5	351¾	9·5	50·0	59·5	179	9
6	388	10·0	59·5	69·5	179	4
7	437¾	8·5	69·5	78·0	119	4
8	454¼	9·5	78·0	87·5	179	9
9	479¼	9·5	87·5	97 0	179	5

Mr. E. M. de Burgh, cofferdams being used as on the South Australian works. At the site of the No. 11 lock, at Mildura, the Victoria authorities are building the lock in an excavated dry channel, the weir being in the river bed.

The Lake Victoria storage scheme makes use, as the name implies, of a natural depression named Lake Victoria, situated some 20 miles east of the South Australian boundary line. The lake is in New South Wales territory. It is one of many natural depressions in Australia, into which water flows from its connecting river at flood time, to flow out again as the river level falls. Its location is indicated in Fig. 1. It lies about four miles north of the Murray, being connected to the river by two channels known as Rufus River and Frenchman's Creek. A plan of the site is shown to a larger scale in Fig. 19, on page 405. This also shows the works involved. The normal low-water level of the lake is at R.L. 173, the datum here referred to being 100 ft. below low water, ordinary spring tide, at Port Adelaide. The regulation scheme raises it to R.L. 195, impounding water to an additional depth of 22 ft. The average depth at full supply level is 23 ft., and the area covered about 41½ sq. miles, giving a useful storage of about 514,000 acre-feet. This storage will be effected in flood time, water being diverted from the Murray by the No. 9 Weir, passed along Frenchman's Creek into the lake, to be subsequently returned to the Murray by way of Rufus River.

The lake is surrounded on all but the south side by slopes of sufficient height to obviate the need of embankments. Along the southern side an embankment about 1¼ miles in length has been necessary. In addition to this bank, about 24 miles of earthwork have been necessary along Frenchman's Creek, as indicated by the heavy black lines in Fig. 19. These banks are all finished at between R.L. 202, near the diversion from the river, and R.L. 200 at Lake Victoria, the actual height ranging between 10 ft. and 16 ft., with 7 ft. clear height above normal flood level. The ground on which the banks have been built was first broken up by ploughing and the banks were constructed by means of horse-drawn scoops, elevating graders, dump waggons, &c. The slope on the water side is 3 to 1, and on the outside 2 to 1 for the upper part, followed by 3 to 1 for the lower. Where wave action is likely to develop, the banks are pitched with 8-in. material on 4 in. of broken metal. The southern shore line of the lake is also protected with pitching a 30-chain timber wave break, but generally the depth of water near the edge of the lake is shallow and in many places sheltered by sand banks.

In addition to the embankment work, the channel of Frenchman's Creek has been straightened and enlarged. The greater part of the channel has been enlarged to a bottom width of 45 ft., with slopes of 3 to 1, some parts being 60 ft. wide, with slopes of 1 to 1; other parts, again, have a bottom width of 52 ft. The capacity of the channel is 100,000 cub. ft. per minute. The discharge channel by way of Rufus River has also been enlarged and improved, the bottom width being generally 100 ft., the maximum capacity being 143,000 cub. ft. per minute, though the agreement limits the discharge from the lake to a maximum of 134,000 cub. ft. per minute.

The flow into and out of the lake will be controlled by an inlet regulator on Frenchman's Creek and an outlet regulator on Rufus River. In addition a control regulator has been installed on Frenchman's Creek about two miles from the point of discharge into the lake. The latter has been installed in view of the great length of the embankments on the inlet channel and the distance of the inlet regulator from the lake, it being obvious that a breach occurring in this length would cause serious loss of water. Views of the controlling and outlet regulators are given in Figs. 20, 21 and 22 above and on page 405. In all three cases the free type of roller sluice has been adopted, counter-weighted, and operated by hand.

The inlet regulator diverts any water not required. This regulator consists of three sluices, of 12 ft. clear width. The gates are 14 ft. 6½ in. wide by 26 ft. high, the lift being 16 ft. The sill level of this regulator is at R.L. 180. The top of the bank at this point is at R.L. 209. The highest known flood level in 47 years at the point where Frenchman's Creek leaves the Murray, 4 miles above the regulator, is recorded as R.L. 203·5.

The control regulator, Fig. 20, has four sluices of 11 ft. 3 in. clear width. The gates are, in this case, 12 ft. 6 in. by 19 ft. 5 in. high, the lift being 19 ft. 5 in. The invert level at this point is R.L. 175·75. A road bridge is carried across the channel at this point. The outlet regulator on Rufus River, illustrated in Figs. 21 and 22, the former showing the up-stream side and the latter the down, has three sluices 15 ft. in the clear. The gates 17 ft. in width by 25 ft. 9 in., with a lift of 10 ft. The sill level is R.L. 170. A timber road bridge has been built across the discharge channel at this point immediately below the regulator, as shown in our views.

The agreement between the States provides that the minimum flow passed down the Murray shall be sufficient to fill Lake Victoria once, and, in addition, to maintain with the water returned from the lake to the Murray a regulated supply from November to February inclusive of 134,000 acre ft.; in March, September and October, 114,000 acre ft.; April, May and August, 94,000 acre ft., and in June and July, 47,000 acre ft. South Australia may be allotted a further supply after New South Wales has utilised up to 1,957,000 acre ft. and Victoria 2,219,000 acre ft. per annum for irrigation. New South Wales settlers over an area of 200,000 acres adjacent to Lake Victoria have the right to use its waters for stock and domestic purposes. As already noted, in years of exceptional draught the Commissioners can vary these amounts as may be desirable.

(To be continued.)

THE REGULATION OF THE MURRAY RIVER.

FIG. 21. UPSTREAM SIDE OF DISCHARGE REGULATOR; RUFUS RIVER.

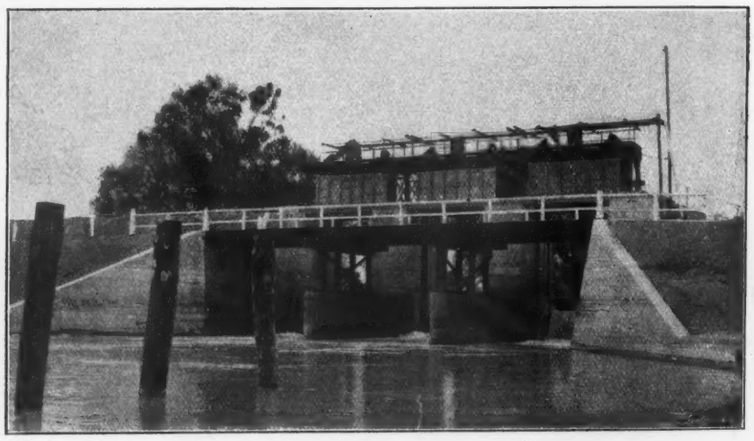


FIG. 22. DOWNSTREAM SIDE OF DISCHARGE REGULATOR; RUFUS RIVER.

SOAPS AND THE THEORY OF COLLOIDS.

THE subject of colloids, Professor J. W. McBain stated in a recent Royal Institution discourse, had suffered from an excess of speculation in the absence of precise experimental evidence. The more carefully a colloid was studied, the less colloidal it appeared to be. That, his further remarks implied, meant that the differences between crystallised substances, like sugar, weak and strong electrolytes (potassium chloride), colloidal electrolytes (soap), suspensoids (arsenious oxide), neutral colloids (starch), and semicolloids (dextrin), which all might be arranged in a closed ring, were merely gradations. Soaps afforded an almost inexhaustible variety of behaviour, but the results were all reproducible. He accepted the theory of Selmi and Nägeli that colloids owed their properties, not to the molecule, but to aggregates of molecules, the micelle, which were to be considered as the colloidal units. The work on soaps, the alkaline salts of the higher fatty acids, many of which had been investigated, strongly supported the micellar theory. Soaps were soluble in little water and underwent hydrolysis into acid and alkali in the presence of much water. The alkalinity therefore increased when more water was added to a soap solution. But the reaction was not so simple as had been supposed. If one compound split into two, the osmotic pressure should increase; but the osmotic pressure of a soap solution was almost that of a real solution like that of undissociated sugar. The electrolytic conductivity of soap was only to a small extent due to the alkali ions, of which few were formed; the ionised micelle itself also conducted the current, but the neutral micelle was the more important constituent.

THE EVOLUTION OF SCIENTIFIC INSTRUMENTS.

It is only natural that man, himself the outcome of biological evolution, should impress the evolutionary character upon those of his productions which raise him most distinctly above his ancestors, and Professor E. N. da C. Andrade, of the Artillery College, Woolwich, had no difficulty in justifying the title of his two lectures on "The Evolution of Scientific Instruments," which he delivered at the Royal Institution on the 10th and 17th ult. There has been, it will be admitted, a general development from the simple to the complex, a production of special forms with special functions, rather than steady progress in one direction, either in size or design. Tentative advances along various lines have sometimes produced permanent types, but have occasionally led to nothing. Just as uncouth giant animals have appeared and disappeared, so unwieldy telescopes and microscopes have been unable to hold their own. Since, however, the development of modern instruments is practically confined to the last three centuries, physical science is in a better position than biology to trace down the defects that caused the extinction of one type and the triumph of another. Telescopes had developed to fantastic lengths before the invention of the achromatic lens admitted of a shorter construction, and thermometers had huge bulbs before fine glass tubes could be drawn.

Professor Andrade restricted himself to the early history of the telescope, microscope, thermometer, barometer, air pump, clock and other tools of the scientific observer, mostly going back to the seventeenth century. Experimental science, he pointed out, was a comparatively modern activity, and Archimedes was probably the only experimental physicist of first distinction in ancient Greece. The development of the astronomical instruments of the Greeks, and later of the Arabians, was remote from modern science, and the form of their instruments had not been governed by chance, but by the limitations of theoretical knowledge and workshop practice of the time. The seventeenth century witnessed the foundation of many learned "academies" in Italy and other countries. The Royal Society, established in 1662, interested itself, like those academies, in the study and construction of "philosophical" instruments. The general keen interest may help to account for the uncertainty as to the originators of some inventions. The telescope was clearly not invented by Roger Bacon (1214–1294), who wrote about glasses by which to see the stars as near as we pleased as vaguely as about carriages without horses. But Leonard Digges may have observed the stars, according to his son's book, "Pantometria," of 1571 (an English book printed in German type), with the aid of "concave and convex glasses of circular and parabolical forms."

Usually the invention is ascribed to one of two Middelburg spectacle-makers, either Lipperhey or Janssen. Galileo made his first "perspicillum" in 1609, after having heard that Stadtholder Prince Maurice of the Netherlands had been able to see a man at two miles distance with the aid of a spy-glass. Thirty years later, Galileo's telescopes were still superior to Dutch glasses, though his combination of a concave and a convex lens had a very small field and gave a virtual image, not admitting the use of cross-hairs or micrometers. Kepler's "astronomical" telescope with two convex lenses of 1611 was made by Scheiner, himself an astronomer who studied sun-spots. Schyrl (1645) introduced the terms ocular and objective. To get over the spherical aberration, Kepler proposed hyperbolic lenses, which Descartes tried to grind in 1628; Christopher Wren also tried to find a solution to this still unsolved problem. Newton attached little importance to spherical aberration; believing dispersion to be proportional to mean refraction, however, he considered the suppression of achromatic aberration to be impossible. Achromatic lenses were manufactured by Dollond in 1757, and possibly before, in 1729, by Chester Moor Hall. Meanwhile the focal length had been increased to get rid of chromatic aberration. Hevel, of Danzig, made a telescope 150 ft. in length, and Huygens dispensed with a tube in his "aerial" telescope, the objective of which he tilted by means of a silk cord. Huygens had previously combined two plano-convex lenses in his achromatic eye-piece, and had also made micrometers which Gascoigne (1640) adapted to telescopes, as described by Hooke in 1667.

Even before that time, telescopes, though yet without micrometers, had been used for angle measurements, and a heated controversy arose between Hevel, who advocated open sights or diopters, and Hooke, whose unpopularity delayed the victory of telescopic sights. Tycho Brahe made his planetary measurements with the aid of four slits or of a mural quadrant. Hooke pointed out that the best of these instruments could only measure to half a degree, and he replaced the vernier, which was invented by Vernier in 1631, by a screw; his bubble level was probably anticipated by Thevenot. Before Newton had constructed his reflecting telescope, adopting that type because he thought that refractors could not avoid chromatic aberration, Mersenne had made a mirror telescope in 1644, and Zucchini may have made one in 1616, while James Gregory's "Gregorian" mirror telescope of 1663 was described by Hooke in 1674. Newton used a spherical mirror and a plane mirror or a reflecting prism, while Cassegrain pierced the main mirror. All these early reflectors, however, were small and of little use.

With the similarly uncertain invention of the microscope, Professor Andrade associated the names of Cornelis Drebbel, of Alkmaar, Janssen and Fontana. Galileo used a microscope at the same time as his telescope, but none of these instruments made any noteworthy discoveries. Hooke's compound microscope was focused by screwing the whole tubular instrument up and down in its stand, and he utilised, like Divini, only the central portion of a large plano-convex eye-piece. Leuwenhoek (1632–1723), and other great microscopists and lens makers, preferred single lenses to microscopes. The pinhole camera obscura of Maurolyeus was known to Leonardo da Vinci. Porta mounted a lens in the hole. The "laterna magica" was described in 1671 by Kircher, who wrote books on everything. His diagrams of the magic lantern were wrong. Mistakes of that kind, perhaps due to the artist's own preferences, were not infrequent.

Passing to thermometers, Professor Andrade pointed out that the early crude temperature indicators relied, like the modern precision instruments, on the expansion of a gas, and on the replacement of water by air. The invention of the thermometer was ascribed to Drebbel, who is also credited with having constructed a submarine boat, and to Fludd. Great improvements were described by Otto von Guericke in his "*Experimenta Magdeburgica de Spatio Vacuo*" (1672). A large copper sphere, provided with a valve to regulate the pressure, was mounted on the top of a U-tube filled with spirits of wine, the indicating device comprising a float, a cord passing over a pulley, and a finger pointing to a scale. The thermometers of the Florentine Accademia del Cimento had long, spiral bulbs fitted with scale blobs of glass, and were altogether very creditable feats of glass-blowing. Hooke and Huygens suggested fixed points, but nothing was really done before Fahrenheit (1688–1738), in Danzig, took the temperature of an ice-salt mixture as his zero, which happened also to be the air temperature of a cold day in 1709. For his upper fixed point he chose the temperature of the human body reckoning 8 by 12 divisions up to 96 deg. He also observed under-cooling and the change of the boiling point of water with the barometer, improved instruments and introduced mercury into the thermometer bulb. Réaumur was the first to calibrate his tubes, which were $\frac{1}{6}$ in. wide, by filling them with liquid, but he opposed the use of mercury as a bulb fluid. The centigrade scale of Celsius, of Upsala, dates from 1742.

After Torricelli's vacuum demonstration of 1643, many experiments were made with vacua. Guericke had a water barometer outside his house, reaching up to the fourth storey. Hooke fitted a recording-wheel device to his barometer. Sir Samuel Morland, who died in 1695, inclined the upper portion of the barometer tube to extend the scale, invented a balance barometer, and, further, a simple calculating machine. The aneroid box of the philosopher Leibnitz (1646–1716) was compressed against the elasticity of a spring. The modern aneroid, in which the case itself acts as a spring, was only invented in 1848 by Vidi.

These instruments benefited by Guericke's invention of the air pump which, as illustrated in his above-mentioned book, was provided with a water seal, an automatic leather valve, and a final-evacuation hand valve. Guericke constructed also an air gun and proved that air had weight, the actual density being later determined by Boyle. His famous Magdeburg-hemisphere experiment was made at the Diet of Regensburg in 1654. The hand valve of Boyle, 1660, was a peg ground into a hole. He worked his pump, which he, like others, immersed in water to keep the air out, by means of a rack and proved, among other things, that the striking of a bell in his receptacle became inaudible in a good vacuum, whilst the Accademia del Cimento failed in similar demonstrations with a bellows and an organ pipe. He also determined the density of mercury in his mercury and water barometers. The inventions of the two-way cock, the two-cylinder pump and the compression pump were made by Denis Papin (1647 to 1714), who worked with Boyle after studying under Huygens. He further improved the first internal-combustion engine of Huygens. Gunpowder was placed, together with a lighted fuse, on the detached bottom of a cylinder, which was then quickly screwed into the cylinder and expelled a piston. Papin fixed the bottom of the cylinder and replaced the gunpowder by water, and thus invented the steam engine, as well as his digester.

Many of the devices of those days had a strikingly modern appearance. Prince Rupert's "Wasser Riegel" (water bolt) looked very much like an anticipation of Gaede's rotary air pump. It consisted of a drum turned eccentrically within a cylinder, the ends of a drum diameter being pressed by a spring against the inside of the cylinder. Schwenter's pump was the prototype of the Roots blower, two toothed wheels in engagement rotating within an oval casing. Reisel's "votatilis suctor et pressor" still awaits modern perfection; this contained an eccentric disc, as in the water bolt, but the disc circumference was set with pivoted fins bearing against the inner wall of the cylinder.

Much ingenuity was also displayed, notably in England and Italy, in the invention of meteorological instruments. The first Florentine hydrometer was a funnel-shaped vessel filled with snow; the water condensing on the outside and dropping off was weighed. Hooke utilised the ears of wild oats and the shrinking and warping of wooden boards as hygroscopic indicators, and also constructed a wind-pressure indicator consisting of a pivoted plate swinging over a graduated arc. He is further credited with the anchor escapement and balance wheel of clocks, which Huygens, probably anticipated by Galileo, had regulated by means of a pendulum.

SMALL HYDRO-ELECTRIC UNITS.

(*Continued from page* 340.)

Pelton Wheels.—The Pelton wheel is an ideal unit for the development of small water powers. It is simple, low in first cost, capable, under suitable conditions, of a high speed, has a high efficiency, and may be closely governed. As stated, however, in the previous section, it is essentially adapted for high heads. It is now so well known to engineers that it is unnecessary to dilate upon its main features. Originally built in the crudest possible form, it is still a machine of extreme simplicity, and, given the necessary conditions for its proper operation, it is entirely suitable for direct-coupling to generators. Despite its simplicity, it has, by virtue of scientific design and improved methods of governing, reached a stage enabling it to be applied to the highest class work, such as the running of alternators in parallel, and to work satisfactorily under the most exacting conditions. Moreover, although built in quite small sizes, the Pelton wheel has been installed in units developing several

SMALL HYDRO-ELECTRIC UNITS.

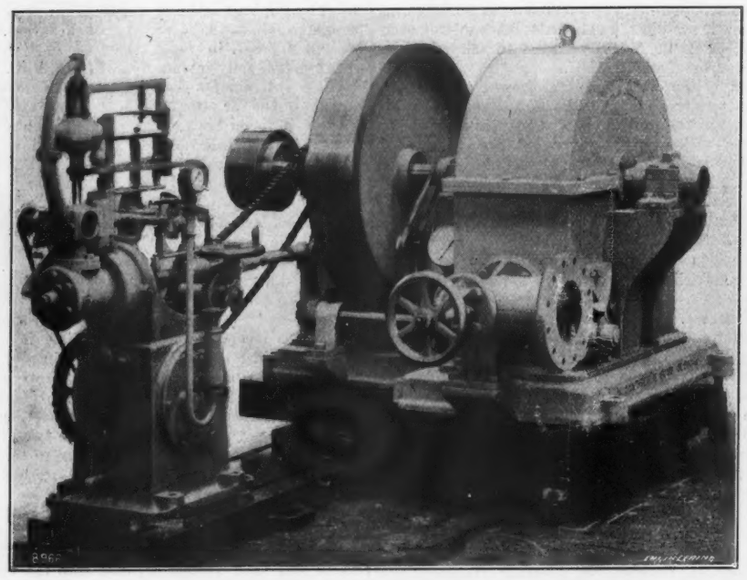


Fig. 18. 100-H.P. Pelton Wheel for 600-Ft. Head.

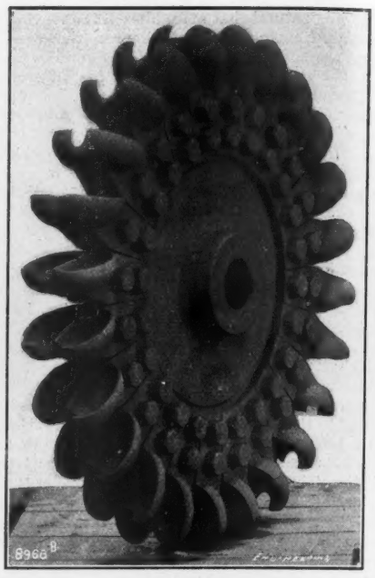


Fig. 19. Runner for 100-H.P. Pelton Wheel.

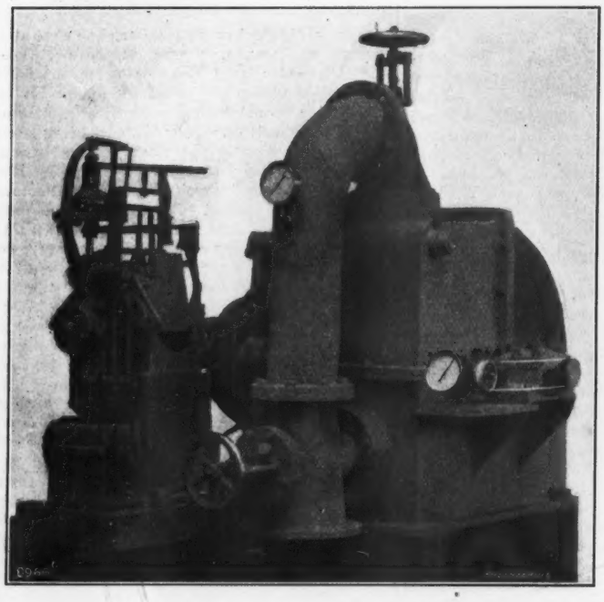


Fig. 20. Pelton Wheel with Two Jets.

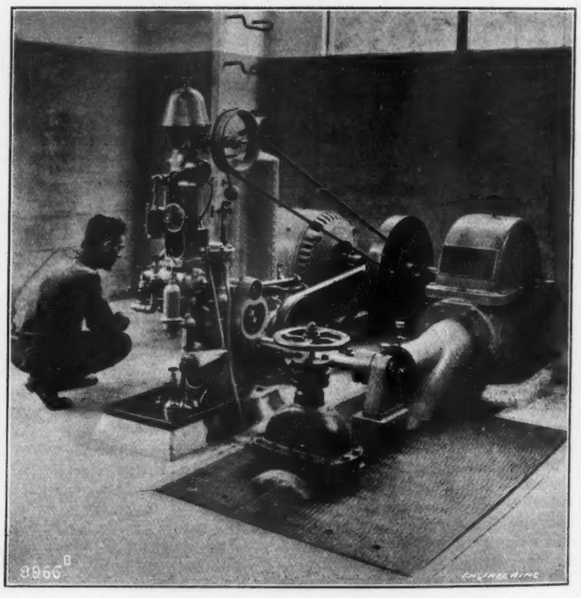


Fig. 21. Small Allis Chalmers Pelton Wheel.

thousand horse-power, but large wheels of this class and those operating under exceptional heads call for special methods of construction.

Fig. 18 shows a good example of a small modern Pelton wheel for hydro-electric work. It is a British design by Messrs. W. Gunther and Sons to develop 100 h.p. under a head of 600 ft. with a speed of 750 r.p.m. The runner of this wheel is shown in Fig. 19, from which the general form of a Pelton runner can be gathered. The governor of the unit is shown on the left-hand side of Fig. 18. While governors will be discussed later, it may be mentioned in passing that in this instance the governor operates the deflector by the linkwork shown, the hand-wheel being for the adjustment of the needle. The provision of a flywheel should be noted. This is now often a recognised adjunct of the modern Pelton wheel when installed for the direct driving of electrical machinery. Its adoption is conducive to steady running, and also assists in close-speed regulation.

Another small Pelton wheel built by the same makers is shown in Fig. 20. In this case there are two nozzles, the needles of which are regulated by the hand wheels shown, while the governor, through the linkwork seen just behind the pressure gauge, actuates the deflectors on each jet. Both the units shown have cases of cast-iron, but many types have the upper part made of sheet steel, and sometimes the lower part is dispensed with and the bearings mounted on the top of a concrete pit. Fig. 21 shows another design for a self-contained unit, but of smaller capacity. A complete unit of American design by the Allis Chalmers Company is seen in Fig. 22. This develops 375 h.p. at 750 r.p.m. operating under a head of 1,380 ft., the wheel being 42 in. in diameter. It will be seen that the governor operates direct on the needle without the use of a deflector. This is not an altogether usual arrangement, but it is a very simple one and well suited to certain conditions.

Buckets.—The essential points wherein the modern Pelton wheel has been improved, both in large and small units, are the buckets and the governor. Although the rotor of a Pelton wheel is a very simple piece of apparatus, the exact form of the bucket has an important bearing upon its efficient operation. In the older forms of Pelton wheel the buckets were of crude design; so long as the water hit them and drove the wheel round, anything in the nature of scientific design was accounted of little moment, while for the powers developed cast-iron was eminently suitable. The higher jet velocities now employed and the greater powers developed, often necessitating very high-speed wheels, demand quite a different class of design. The buckets, besides being of such a form as to convert the maximum amount of the energy available into useful work, must be made of material suitable for withstanding constant and severe impact of the jet, besides considerable centrifugal force. Steel,

SMALL HYDRO-ELECTRIC UNITS.

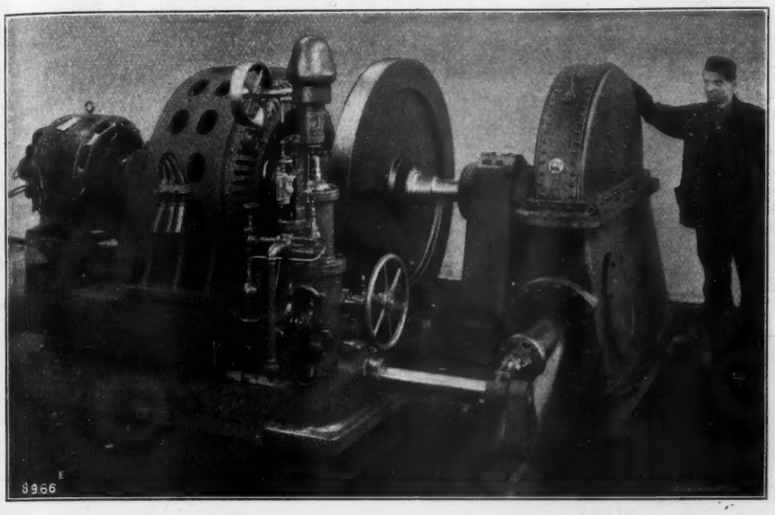
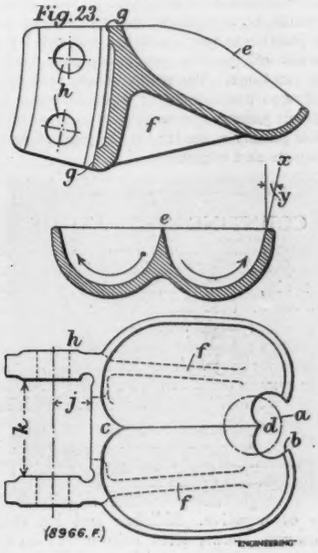


Fig. 22. 375-H.P. Pelton Wheel for 1,380-Ft. Head.



therefore, is generally used in place of cast-iron formerly employed.

The jet of water issuing from a properly designed nozzle is circular in section and, under running conditions, should appear as a solid bar of glass. As the on-coming bucket comes into the line of the jet the position of the latter would be as at *a* in Fig. 23. In other words, the on-coming bucket cuts out part of the jet from the retiring one, allowing the remainder to escape through gap, giving a final supply of energy to the bucket which previously received the full discharge. As rotation continues, the jet strikes the bucket further away from the gap till the succeeding one in turn cuts it off entirely. The dividing edge or splitter *c d* cuts the jet in half, and by reference to the cross-section it will be seen that the water must travel round to the side of the bucket, as shown by the arrows, issuing finally in the direction of *x*. Thus, its direction of exit is nearly 180 deg. from its direction of entry. Theoretically it should, if all its energy were to be expended, be turned through a complete angle of 180 deg., but in practice this is impossible. There is the little discrepancy shown by the angle *y*. This is essential in order to permit of the spent water escaping clear of the on-coming buckets, any fouling thereof by the spent water leading, obviously, to loss of power. With a bucket designed on these lines the spent water should fall away quietly, irrespective of either the original volume or the velocity of the jet. It will be noted that the splitter is quite sharp at *e*, and the curved portion on each side of it is always polished in the best work. The bucket is strengthened by ribs *f f*, while faces *g g* are machined to the radius of the wheel rim so as to bear hard upon it when attached by fitted bolts through holes *h h*. The lugs are machined, the distance denoted by *k* being a push fit on the wheel rim.

(To be continued.)

POSTURE AND REST IN MUSCULAR WORK.

The attitude assumed by a worker and intervals of rest between spells of exertion are well known to affect the efficiency of the work. Probably the best instance in practice of the extraordinary differences that may be produced by the judicious selection of these variables is F. W. Taylor's "first-class" shifter of pig-iron, who by strict attention to Taylor's directions and the encouragement of a differential piece-work rate managed to do about four times his previous amount, which was no less than other people's. Taylor, with the help of Barth, constructed in fact a formula for the proportion of time loading to time resting for different loads, but the basis of it seems to have been empirical, and little or nothing is known on the subject in general terms. Whether anything ever will be, or whether the anatomical and nervous idiosyncracies of individuals will always mask any such general truths, can only be discovered by trying. It is certain that the matter is of considerable importance, and at present not nearly enough has been done to warrant any inference that much more general data are obtainable than are now at our disposal.

The Industrial Fatigue Research Board has just published two contributions to this study,* which, without adding greatly to available conclusions, suggest lines of investigation that may prove to be useful. One is by Miss E. M. Bedale, who has investigated the expenditure of energy at which a particular woman carried defined loads in standard conditions in eight different ways. Half these experiments were made in conjunction with one of the Home Office officials, Dr. E. M. Hewitt, and all were apparently under the general supervision of Professor E. F. Cathcart, who has written an introduction. The expenditure of energy during work was measured by the production of carbon dioxide (collected at intervals in a Douglas-Haldane bag) and consumption of oxygen during the observations, less the normal production and consumption as measured daily after rest. In a series of very instructive shadow-photographs, taken by Mrs. Cathcart, the subject is shown in each posture under a load of 40 lb., and the poise and position of equilibrium are well illustrated. The loads varied from 20 lb. to 50 lb.—in two instances to 60 lb.—and were carried for an hour at the rate of 2·8 m.p.h. in circuits of 100 yards, alternately loaded and unloaded, the air being sampled for 2½ minutes three times an hour. For all weights the least consumption of oxygen was obtained with the weight divided between two pails and carried over a yoke, and the most, which was something under half as much again, was, with one exception, with the weight resting on the hip; in all other postures the suitability of the method varied with the load. The author found local strain, posture, gait and chest freedom to be interacting factors, the relative importance of which varies with the load; the advantage of yoke-carrying is that it imposes no constraint in any of these respects, and the disadvantage of the hip-carrying that it does so in all of them. The observations seem to be really preliminary, and if pursued further may lead to general conclusions; but within limits it seems possible that individual peculiarities may introduce variations in the convenience and cost of each method, and when preliminary general conclusions have been reached they will doubtless have to be checked with an open mind on a number of individuals to distinguish effects that arise from the individual construction and habits of the subjects from those that are common to all persons.

A similar result seems to emerge from the report of Dr. H. M. Vernon on the influence of rest pauses and change of posture on the capacity for muscular work. This report is based on experiments on the author himself, and to a large extent also on another subject, with a dynamometer of the author's design, in which the subject pulls vertically upwards against a spring. The vigour with which the work was carried out may be judged by the fact that in one series of experiments Dr. Vernon pulled upwards of 250 lb. no less than 750 times in 20 minutes twice a day—more than this is said quite plausibly to have fatigued him—and it is to be hoped that, whatever experimental sequel may be given to the present study, it will occur while Dr. Vernon retains his remarkable physical vigour. An important observation, which indicates a fundamental difference between dynamometer experiments and the earlier use of the ergograph, is that the heavy muscular movements can be continued at full strength even in the presence of fatigue, whereas the smaller muscular contractions observed with the ergograph are affected and may be ultimately stopped by fatigue. This conclusion is based on experiments extending sometimes as long as 88 minutes, in which it was found that after the first few minutes the maximum pull fell to a steady level and stayed there for the rest of the period, in spite of more or less continuously increasing fatigue. Another result has been to confirm the importance of changing posture, both during rest pauses and during work; and it is possible that for this purpose, and thus probably to increase the circulation in the muscles at work, it may be desirable to interpose occasional movements with no direct advantage to the mechanical purpose of the work, just to promote circulation where it is most wanted.

The results do not give any substantial addition to what little guidance is available at present as to the best duration and incidence of rest pauses, and some considerable differences between Dr. Vernon and his alternative subject seem to indicate that a number of different subjects will have to be examined before general conclusions can be drawn. It may perhaps be hoped that in constructing the scheme of later experiments Dr. Vernon may be associated with an engineer accustomed to shop work. For practical purposes, muscular movements are a good deal more

* Report No. 29. The Effects of Posture and Rest in Muscular Work. H.M. Stationery Office. 2*s.* 6*d.* net.

complicated and affected by variables than may be obtained and are desired in the technique of laboratories. This by no means involves the view that laboratory work is not valuable; but sooner or later it must be recognised that the utmost simplification possible in practical work will still leave the movements of practice more complex than elementary motions. To assess which complexities will represent practice fairly while allowing proper distinction among physiological or anatomical factors, is plainly a matter for the joint attention of physiologists and engineers.

COUNTING THE ATOMS.

IN commencing his concluding lecture on the above subject at the Royal Institution on Saturday, the 21st ult., Sir Ernest Rutherford, said that on the last occasion he had given an account of the very beautiful and very accurate methods by which Millikan had determined the value of the unit electric charge. The plan followed was to vary the charge on a droplet of oil by letting the latter pick up neighbouring ions. It followed, therefore, that the measurements made, gave the charges carried by these ions. In general, when a gas was ionised by the action of X-rays, the greater proportion of the ions formed were bearers of but a single charge which might be either positive or negative. Millikan and his students had, however, shown that helium was an exception to this rule, ions with two charges being much more frequently met with than in the case of other gases. This illustrated the fact that the atom of helium had two electrons external to the nucleus, so that when an α particle passed near, it removed both, the orbits of the two electrons being probably coupled.

The question naturally arose as to whether the charge carried by the hydrogen atom in electrolysis was the ultimate unit of electricity, or whether it was possible that smaller charges existed. Taken as a whole the evidence was conclusive, in favour of the former alternative, though Ehrenhart, of Vienna, claimed to have met with smaller charges. The experiments which led him to this view had, however, been made with very small drops. With such drops the Brownian movements were more rapid, making it difficult to fix the true diameter of the particles or to apply Stoke's law.

As pointed out in the last lecture, once the unit charge of electricity was determined all other atomic magnitudes followed at once. Two types of particles were available for measuring the unit charge, viz., the electron and the α particle. The electron carried a negative charge of $4{\cdot}77 \times 10^{-10}$ electrostatic units. The mass of the electron had been determined by sending a fine beam or pencil of them through a magnetic field and observing the deflection produced. The pencil of rays was next passed between parallel plates connected to the opposite poles of a battery, and the deflection produced by this electrostatic field was also measured. The deflection produced by the magnetic field was proportional to $\frac{mu}{e}$, where m denoted the mass of the particle, e the charge carried, and u the speed of the particle. On the other hand, the electrostatic field produced a deflection proportional to $\frac{m}{e}\frac{u^2}{c}$. The one deflection, therefore, depended on the momentum of the particle, and the other on its kinetic energy. By combining the two sets of observations, we could deduce both u and the ratio $\frac{e}{m}$, which for low speeds was thus found to be equal to $1{\cdot}77 \times 10^7$ electromagnetic units. We knew from electrolysis that in the case of an atom of unit mass (oxygen = 16) the ratio $\frac{e}{m}$ would be 9,650. Hence, on dividing one by the other, the mass m_0 of the electron (at low speeds) was found to be $\frac{1}{1840}$ on the same scale as that on which the mass of the oxygen atom was 16. The electron was, therefore, the lightest body known.

The α particle which was ejected spontaneously by various radio-active bodies, carried two charges. Bragg had shown that these particles had a definite range in air. Through this they would travel a certain definite distance, ionising the gases and then the apparent effects vanished. The question arose as to what these particles were.

This was settled by Dr. Robinson, working in conjunction with the speaker in 1912-13. They used as a source of the rays an "emanation tube" containing radon (radium emanation). The tube was of very fine bore and had walls so thin that the α particles were shot through the glass. A fine band of them was separated out by means of stops, and passed through a magnetic field on to a photographic plate. The effect of this field was to bend the rays very slightly, and by reversing it a deflection in the opposite direction was obtained. On development of the plate, bands were obtained, as shown in Fig. 9, the distance between which was twice the deflection produced by the field.

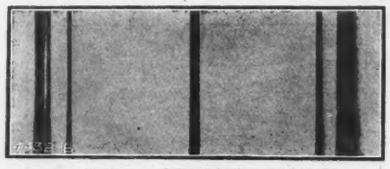


FIG. 9.

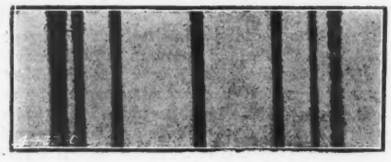
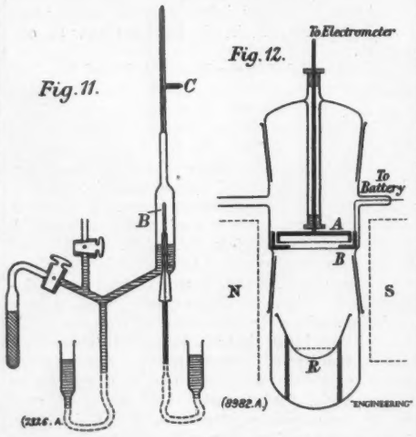


FIG. 10.



In the figure the central band was obtained when the magnetic field was suppressed. It would be seen that the side bands were triple. This was due to the fact that associated with the emanation in the tube was radium A, radium B and radium C. Radium B ejected β particles only, which did not reach the plate, but the α particles emitted by radium A and radium C travelled at different speeds, which again were different from the speed of the α particles ejected by the emanation. Each type was responsible for one of the bands shown. The experiment was then repeated, substituting an electrostatic for the magnetic field, and the photograph reproduced in Fig. 10 was obtained. Here it would be seen that the bands were more widely separated than before, which was due to the fact that the deflection in the electrostatic field was proportional to the square of the speed of a particle, so that small differences in the velocity showed up better than in the photograph obtained with the magnetic field. The work took a year or two to complete, but their final result showed that within one part in 400 or 500 the value of $\frac{e}{m}$ was 4,820 electromagnetic units, whereas the known value for the hydrogen atom in electrolysis (or, rather, for an imaginary atom of unit atomic weight) was 9,650. The density of helium was 4, so that if each α particle carried only one charge the ratio $\frac{e}{m}$ should have been 2412. The number found was twice this, which showed that the particle carried two charges, the α particle being a helium atom with two electrons removed. This conclusion was, in the first instance, a deduction. To confirm it the speaker and Dr. Royds had used the apparatus shown in Fig. 11. Here A was an exhausted vessel, B an emanation tube, and C a fine "spectrum tube," into which any gas collected could be compressed, in order to have its spectrum examined. The α particles shot through the walls of the emanation tube buried themselves in the glass wall of the vessel A. After some time, however, they diffused out of the glass. At the end of 24 hours the gas thus collected was compressed into the spectrum tube and was then found to give the yellow line of helium, and in three or four days sufficient of the gas collected to give the complete spectrum. It still remained to make a direct measurement of the charge carried by each particle. This was practicable, because methods had been developed for counting the number of particles emitted from a milligramme of radium per second. The number was incredibly large, but was definitely known. The α particles shot from a source at R, Fig. 12, passed through a thin aluminium sheet at B and were caught by the inverted dish A, which was essentially a Faraday cylinder. The particles gave up their charges to this cylinder, which thus became positively charged. By measuring this charge and dividing it by the known number of the α particles, they found that the charge on each was $9{\cdot}3 \times 10^{-10}$ electrostatic units. Hence the unit charge was half this, or $4{\cdot}65 \times 10^{-10}$ electrostatic units. This was the first reasonably accurate measurement of the value of the unit charge. The accepted value at the time was $4{\cdot}35 \times 10^{-10}$ units, and it was a big jump from this to 4·65. The true value as shown by Millikan was 4·77.

The varied methods of determining atomic magnitudes described had, Sir Ernest proceeded, led to reasonably concordant results, but some values were more likely to be accurate than others. The accepted value for the number of molecules in a cubic centimetre of gas at standard temperature and pressure was $2{\cdot}7 \times 10^{19}$. This was an enormous number, and it looked as if it would ever be impossible to detect effects due to a single molecule. Some atoms, however, such as the α particles, were differentiated from the normal by their speed by carrying an electric charge, and there were a number of methods by which the effects produced by a single α particle could be detected. This was first done by Crookes, who, observing the wavering glow produced on a zinc sulphide screen by an α-ray bombardment, saw that this was resolved into very fine points of light which came and went with great rapidity, each impact of an α particle producing a visible flash of light. A similar effect was obtained with a Willemite screen, but with this the scintillations were fewer. With the zinc sulphide screen, however, each α particle was effective in producing its flash. As the transformation of the energy of the particle into light was very inefficient, the efficiency being $\frac{1}{300}$ almost, this result was a striking indication of the great energy associated with the particle. It was therefore to be expected that they would affect a photographic plate, and Fig. 13 showed that this was the case. The photograph was obtained by touching the plate with the point of a needle on which radioactive matter had been deposited. After development the plate was magnified about 5,000 times, with the result shown. The tracks were due to the α particles and the actual distance of travel was only about $\frac{1}{15}$ mm.

During the years 1907–10, Dr. Geiger and the speaker had devised methods for counting the number of particles ejected in a given time. The apparatus first used was represented in Fig. 14. An emanation tube was placed in the vessel G and shot α particles into the detecting vessel A. Down the centre of this vessel passed a wire B, and between this wire and the wall of A a potential difference

was maintained, so high that the discharge was on the verge of passing. The α particles entering the vessel ionised the gas there, and these ions acquired so high a speed under the electric field to which they were subjected that they ionised in their turn molecules with which they collided. The effect was cumulative, the ions produced by each collision becoming ionisers in their turn. The net result was that the effect of each α particle entering A was magnified by 1,000 to 10,000. In the final arrangement the entrance of the particle was recorded by the deflection of an electrometer constituted out of a quartz fibre strung between two oppositely charged plates, as indicated diagrammatically in Fig. 15. The instrument was coupled up to the detecting vessel, and the entrance of each α particle was accompanied by a throw of the fibre, which was recorded photographically. A typical record was represented in Fig. 16. In this way it was quite easy to count as many as 1,000 or even 2,000 particles per minute. The number per minute was not uniform, but followed the laws of chance, the following being typical figures :—

	Number of Throws.	Magnitude of Throws in Scale Divisions.
1st minute	4	10 12 10 11
2nd ,, ...	3	10 11 8
3rd ,, ...	5	10 9 13 8 12
4th ,, ...	4	18 8 12
5th ,, ...	3	10 6 10
6th ,, ...	4	9 10 12 10
7th ,, ...	2	10 11
8th ,, ...	3	11 13 8
9th ,, ...	3	8 20
10th ,, ...	4	8 12 14 6
	Average = 3·5	Average throw = 10 div.

Geiger had simplified the detecting vessel, replacing the central wire by a fine-pointed needle, as indicated in Fig. 17. Mr. Appleton had had examined, under a microscope, the working of these Geiger counters, and had observed that at each discharge there was a little spark at the point of the needle. With matters properly adjusted the current cut itself off automatically, but if the P.D. between needle and wall were too great, the current continued.

With this apparatus it was quite possible to get a considerable current as the result of the entrance of a single α particle, and the effect could be still further magnified by using a valve, so that a lamp could be lighted up or a relay operated.

In the way described, it had been found that one gramme of radium "in equilibrium," liberated $1{\cdot}36 \times 10^{11}$ α particles in a second, or $4{\cdot}28 \times 10^{18}$ in a year. The volume of helium liberated per year was $0{\cdot}156$ c.c., so that there were $2{\cdot}74 \times 10^{19}$ atoms in a c.c. of helium. This figure obtained 15 years ago, was very close to the present accepted value, which was $2{\cdot}70 \times 10^{19}$.

The most striking method of demonstrating effects due to a single particle was devised by Mr. C. T. R. Wilson, who shot α particles, electrons, or X-rays through super-saturated air. Condensation occurred on the ions produced in the track of the particle, so that each invisible ion became the nucleus of a droplet of water of visible dimensions. The tracks could, therefore, be photographed, and we could thus, not merely detect, but obtain a full record of the active life of an α particle, which endured but some 10^{-10}—10^{-11} of a second.

Typical tracks from Thorium C. were represented in Fig. 18, which showed clearly the very definite range of the particles, of which 65 per cent. had a range of 8·6 cm. The photograph of a single track was reproduced on Fig. 19. Here the little blob at the commencement should be noted. This was due to the recoil of the atom out of which the α particle was shot. The track of the latter was almost straight, although it ploughed through about 200,000 atoms in its path. Only near the end did this path become a little unsteady. Other tracks more highly magnified were represented in Fig. 20. Here the little blobs along the sides of the tracks were due to electrons shot out from the atoms with which the α particle collided. On the same plate a wavering track, due to a β particle, could be seen. The density was small as the β particle was an ineffective ioniser. Fig. 21, showed another β track, along which it would be seen there were a series of dots occurring in pairs. These were due to the positive and negative parts of the molecules ionised by the passage of the ray.

Mr. Blackett had secured photographs recording the collision of an α particle with a helium atom. One of these was reproduced in Fig. 22. The atom of helium and the α particle being of equal mass the real angle between the tracks was 90 deg.

In conclusion, Sir Ernest said that during the last 25 years we had been able to determine constants with a precision, which could never be anticipated. We now knew, with considerable accuracy, the actual mass of every atom known to the chemist, and we had been able to show that in certain conditions, individual atoms might produce detectable effects. Kelvin had said that we never really knew anything until we could measure it. As matters stood, we now knew the value of the atomic constants within at least 1 per cent., and perhaps within 1 in a 1,000. Moreover, we had not merely succeeded in counting the atoms, but we had also learnt something of their structure.

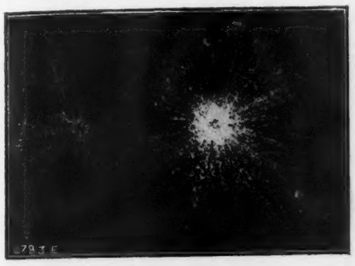


FIG. 13.

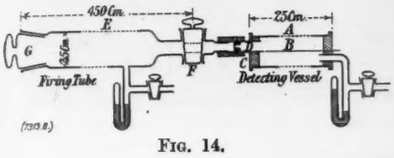


FIG. 14.

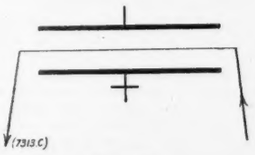


FIG. 15.

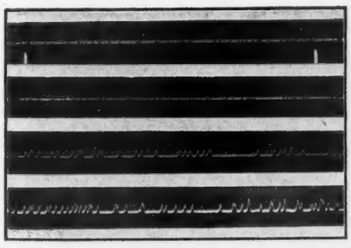


FIG. 16.

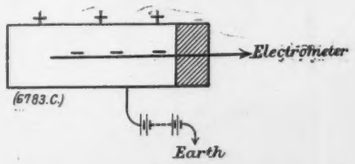


FIG. 17.

FIG. 18.

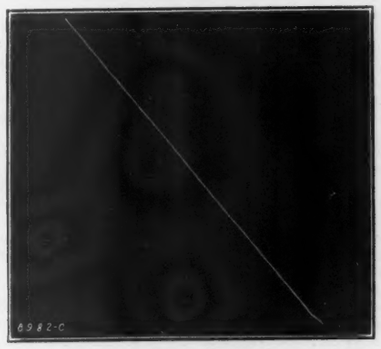


FIG. 19.

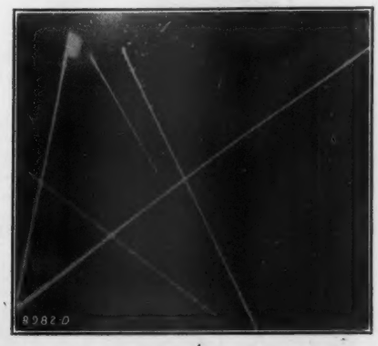


FIG. 20.

FIG. 21.

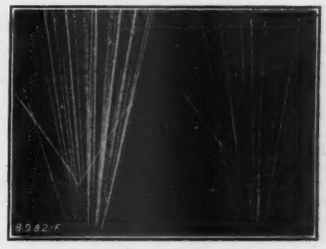


FIG. 22.

PUMPING PLANT FOR THE RAND WATER BOARD.

CONSTRUCTED BY MESSRS. W. H. ALLEN, SONS AND CO., LIMITED, ENGINEERS, BEDFORD.

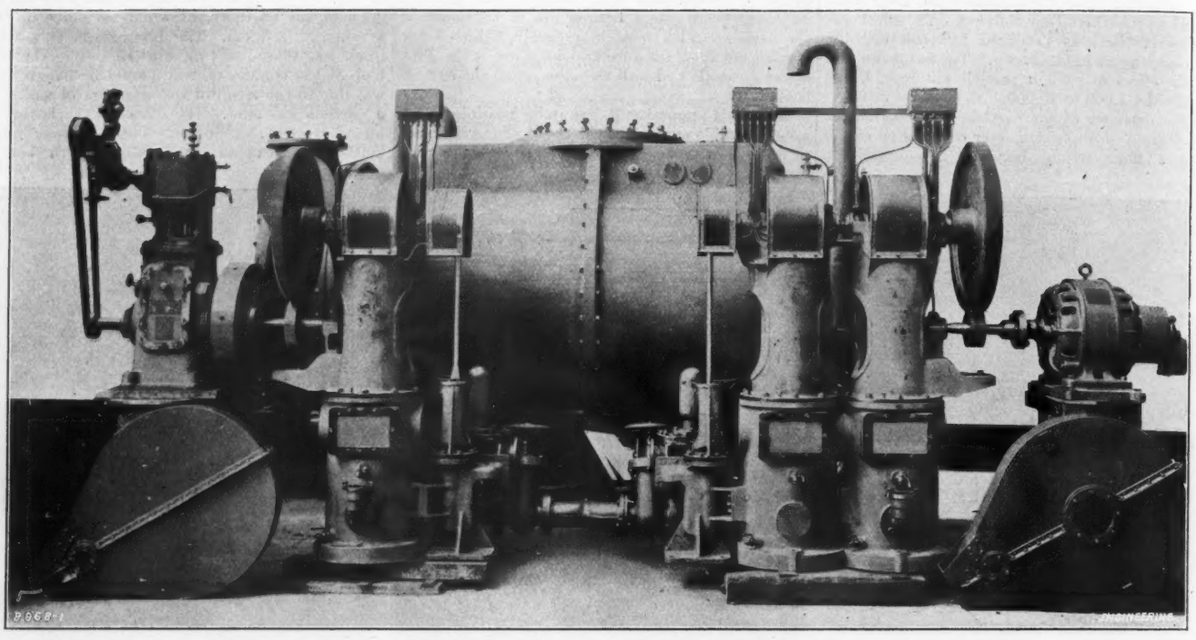


FIG. 12. SURFACE CONDENSER ON STEAM TURBINES DRIVING CENTRIFUGAL PUMPS.

STEAM TURBINE-DRIVEN PUMPS FOR THE RAND WATER BOARD.

ON Plate XXVIII, and on pages 413 and 420 and above, we illustrate two duplicate sets of steam-driven centrifugals supplied by Messrs. W. H. Allen, Sons and Co., Limited, to the Rand Water Board for pumping a supply of water from the filter and sedimentation station which has been provided at Vereeniging on the Vaal River (where a large impounding reservoir has been constructed) to Zwartkopjes, a distance of about 25 miles. The pumps were each required to be capable of delivering at "overload" 6,000,000 gallons per 24 hours, against a total head of 565 ft., which corresponds to, roughly, 920 brake horse-power.

Sections through the main machinery room are reproduced in Figs. 1, 3 and 4, Plate XXVIII, and a plan in Fig. 2, from which it will be seen that the plant includes, in addition to the pumps already mentioned, two turbo-alternators. These have also been supplied by Messrs. Allen, and furnish the current for driving some subsidiary pumping machinery, such as the centrifugal pumps at the intake on the Vaal River, which is about a mile distant from the main pumping station. These intake pumps deliver the water to sedimentation tanks at the main station. After passing through these tanks the water is filtered and then enters an underground storage reservoir, from which it is drawn by another set of electrically driven centrifugals and sent through the station condensers. On leaving these the water is chlorinated and then stored in an open reservoir, from which the main pumps take their supply through the main suction pipe, which, as represented in Fig. 2, passes along the centre line of the building. The discharge pipe, on the other hand, is arranged to run near the front wall of the building.

To avoid water hammer the Rand Water Board have provided a 6-in. pipe connecting the discharge pipe directly with the suction pipe. This connecting pipe is shown at A, Fig. 2, and, as will be seen, is fitted with a 6-in. spring relief valve, which opens automatically should the pressure on the delivery main exceed a certain limit. The arrangement has proved very satisfactory. On stopping the turbine, by tripping the emergency gear, the highest pressure recorded in the delivery main was only 17 per cent. in excess of the normal, whilst, on screwing down the relief valve and stopping the turbine very gradually, the pressure rose to 37 per cent. above the limit.

Cross sections through the power house are represented in Figs. 3 and 4, from which it will be seen that the method of carrying the turbines marks a departure from the usual practice, in which the weight is carried down to ground level, as directly as possible, by concrete piers built up immediately under the bed plate. In this case it was considered desirable to make access to the condensers and auxiliaries as free as possible. To this end the turbines and pumps are carried on a strong floor built up of steel and concrete, thus getting rid of any obstructions below.

The turbines are designed to work with steam supplied at 200 lb. gauge pressure, and at a temperature of 550 deg. F., whilst the equivalent of a 28-in. vacuum was specified in the condensers. A longitudinal section through the turbines supplied by Messrs. Allen, is represented in Fig. 5, whilst Fig. 6 shows the arrangement of the governor gear and oil pump. A general view of the unit is reproduced in Fig. 16, page 420, which shows it under test at the builders' works.

As will be seen, the turbine is of the impulse type, having eight stages, 2 ft. 4 in. in mean diameter. The designed speed of rotation is 4,700 r.p.m. on normal load, at which it develops 740 brake horse-power. It can, however, be run at 5,000 r.p.m., at which it generates 920 brake horse-power. The corresponding speed of the pumps is 955 r.p.m., and the delivery under these conditions will be 4,160 gallons per minute, against a head of 565 ft. In normal working the pump speed is 900 r.p.m., and the delivery 3,830 gallons per minute against a head of 510 ft.

As shown in Fig. 5, the steam inlet to the turbine is arranged in the lower half of that casing, so that the upper half can be removed for purposes of inspection or repair without the necessity of breaking pipe joints. The high temperature and high pressure are confined to a cast-steel nozzle box, with a consequent reduction in the liability of the casing to distortion. This arrangement also makes it possible without risk, to construct the casing wholly of cast-iron. The diaphragm between the stages are also for the most part of cast-iron, with steel partition plates cast in, though steel has been used for the two diaphragms nearest the steam inlet. The wheels are of high-tensile steel and the blading of phosphor bronze. Each wheel was carefully balanced before mounting in place. A Michell thrust bearing is fitted to take any residual end thrust.

A somewhat wide range of running speeds had to be provided, as the specifications required the pumps to work satisfactorily at all heads between 415 ft. and 565 ft. The governor valves are controlled by oil-operated relays, taking their supply from the pressure pipes of the lubricating system. An emergency governor of the unbalanced ring type is fitted in the governor spindle, as indicated in Fig. 6, and is designed to shut off steam should the speed exceed 5,500 r.p.m.

As shown, an oil pump of the gear type is fitted at the bottom of the governor spindle, but an auxiliary steam-driven oil pump is also provided, which starts up automatically should the necessity arise. This steam-driven pump is also used in starting up and in stopping the turbine, to ensure in the one case that the bearings are fully primed, and, in the other, that the oil supply shall be fully maintained until the turbine actually comes to rest.

The pumps are designed to run at from 800 to 955 revolutions per minute, according to the demand for water, and are coupled to the turbine by a single reduction gear, sections through which are reproduced in Figs. 8, 9 and 10, Plate XXVIII. The pinion shaft is coupled to the turbine by a flexible coupling of the claw type, indicated in Fig. 8. Another section through this coupling is given in Fig. 7. The pinions are of oil hardened nickel steel, forged solid with their shafts; whilst the main gear wheel has a cast-iron hub with mild steel rims shrunk and pinned on. The oil sprayers for lubricating the teeth are fed from the oil mains of the turbine. A strainer is provided at the bottom of the casing, as indicated in Fig. 11.

A longitudinal section through the pump is reproduced in Fig. 13, page 413. As will be seen it has four stages. The suction branch is 18 in. in diameter and the delivery branch 16 in. The casing is of cast-iron and the impellers of bronze, which has also been used for the guide passage and diffusers. The complete pump consists 4 units in series, bolted together by the long through bolts shown. The impellers are 23¾ in. in diameter and at maximum load run at 955 revolutions per minute, whilst the maximum head is about 565 ft. corresponding to a pressure of about 240 lb. per square inch. The whole casing was subjected a test pressure of 440 lb. per square inch at the builders works.

The axial thrust is taken by an hydraulic balance as indicated to the right of Fig. 13, which is supplemented by a spring supported Michell thrust bearing, which has been added to provide against surges in the long pipe line. The spring allows the hydraulic balance to function, whilst at the same time relieving it of a constant propulsion of the total thrust. The leak-off from the hydraulic balance is diverted into a funnel fitted above the gland at the suction side of the pump (see Fig. 13), and for this gland it provides the sealing water. As will be seen the gland at the delivery end of the pump is only subject to the pressure of the leakage water from the hydraulic balance.

In starting up, the pumps are in general primed from the delivery main, but the air pumps belonging to the condensing plant can be used for this purpose should the need arise.

Each unit consisting of turbine, gearing and pump is mounted on the one bed plate, thus ensuring that these

PUMPING PLANT FOR THE RAND WATER BOARD.

CONSTRUCTED BY MESSRS. W. H. ALLEN, SONS AND CO., LIMITED, ENGINEERS, BEDFORD.

Fig. 13.

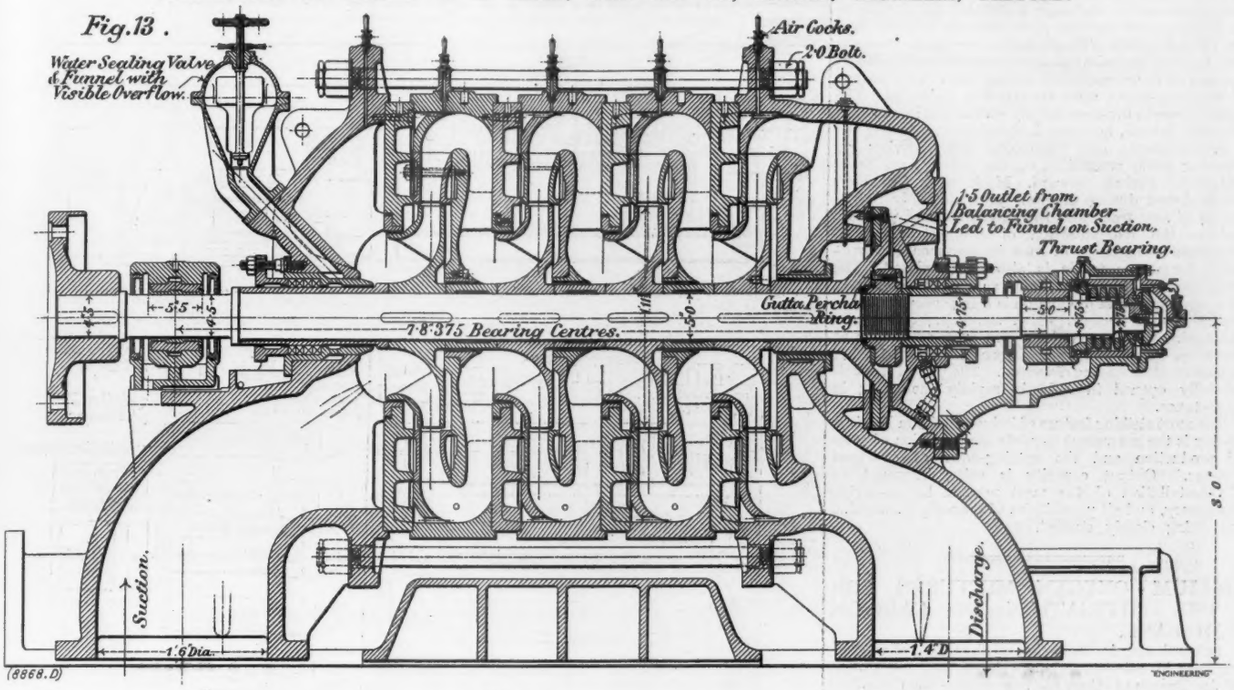


Fig. 14

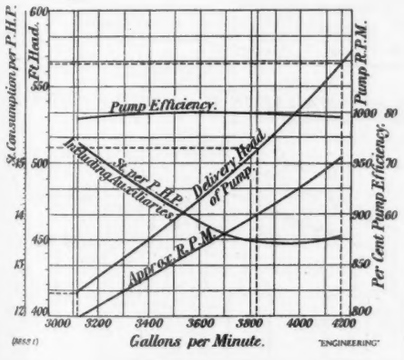
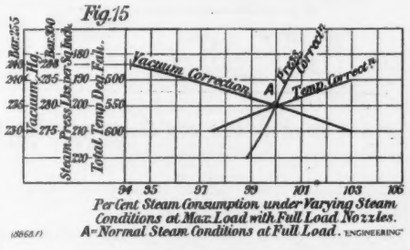


Fig. 15


Steam Press. Bar. Lbs. Sq. Inch.
Vacuum Hg.
Total Temp. Deg. Fah.
Vacuum Correction
Temp. Correction
A
94 95 97 99 101 103 105
Per Cent Steam Consumption under Varying Steam Conditions at Max. Load with Full Load Nozzles.
A=Normal Steam Conditions at Full Load.
"ENGINEERING"

different components shall remain permanently in alignment.

Each turbine has its own condenser (see Fig. 12, page 412), which is designed to deal with 7,560 lb. of steam per hour on normal full load. The cooling surface provided measures 2,000 sq. ft. in area, the tubes being 1 in. in diameter and 800 in number, and the condensers are guaranteed to yield full duty with 15 per cent. of the tubes plugged and out of action. There are two passes for the water, which as already mentioned is sent through the condensers on its way from the filters to the storage reservoir. Provision is also made however for discharging the condensing water into the main pump suctions if required. Owing to the ample water supply the temperature rise in passing through the condenser is small. Duplicate "Edwards" air pumps are provided, one set being driven by a single-cylinder high-speed engine and the other electrically.

Provision is made for running the turbines on atmosphere should the need arise, and a large sluice valve has accordingly been provided between each turbine and its condenser.

The units were all tested at the builders works before dispatch to South Africa.

The general characteristics of the plant are represented in the curves reproduced in Fig. 14, where it will be seen that the pump efficiency averages 80 per cent. over a very long range of performance. Tests made on site showed that the steam consumption corrected to standard conditions by the curves reproduced in Fig. 15 was 13·13 lb. per pump horse-power for the first set completed and 13·02 for the second.

The contract included also the provision of two electric generating sets of a rated capacity of 350 kw. A view of one of these generators is reproduced in Fig. 17, page 420. They supply alternating current at 2,200 volts, the periodicity being 50 cycles per second. As tested at the makers' works the following figures were recorded:

Load.	Steam Rate per kw.-hour.	
	No. 1 set. Lb.	No. 2 set. Lb.
15 per cent. overload	14·22	13·9
Full load	14·76	14·6
¾ load	15·1	15·0
½ load	17·8	17·9

The plant has now been in active service for many months and the engineers to the board have expressed their entire satisfaction with its performance.

S.S. "CITY OF MANDALAY."—Built for the City Line of the Ellerman Lines, Limited, of Liverpool, by Messrs. Swan, Hunter and Wigham Richardson, Limited, at Wallsend, the City of Mandalay, a single-screw steamship, recently ran a successful trial trip off the mouth of the River Tyne. The vessel is 443 ft. in length and 57 ft. 6 in. in breadth, and has been built to the requirements of the highest class of Lloyd's Register. She has a cruiser-shaped stern, with poop and combined bridge and forecastle, is rigged as a two-masted fore and aft schooner, and can carry about 11,500 tons. The ship has 5 cargo holds, with 5 large hatchways and 18 steel cargo derricks, together with 17 steam winches. Steam fire-extinguishing pipes have been fitted to all holds, between decks and bunkers. The propelling machinery, constructed by the Wallsend Slipway and Engineering Company, Limited, consists of inverted, direct-acting, triple-expansion type engines, with three cranks driving the propeller, whilst the three single-ended boilers are arranged for working with forced draught and Howden-Ljungström air preheaters, and are fitted with superheaters. The working pressure is 225 lb. per square inch.

INDUSTRIAL CONDITIONS IN BELGIUM.

ERRATIC exchange fluctuations during the year 1924 were the source of much anxiety and uncertainty in Belgium commercial and industrial circles. According to the Report on the Economic and Financial Conditions in Belgium, prepared by Mr. J. Picton Bagge, and issued by the Department of Overseas Trade, prices were thereby thrown into a state of chaos and foreign trade was temporarily jeopardised. No bankruptcies resulted, however, and this coupled with the fact that unemployment increased only slightly is indicative of the sound basis upon which Belgian business rests. In spite of inevitable wage-readjustments no strikes occurred, which speaks well of the good understanding which exists between employers and employees. Confidence returned towards the autumn and trade activities became more normal.

The year was a difficult one for the coal trade, foreign competition from Germany having proved especially severe, and, in addition, French, British, and Dutch coal was purchased in large quantities. Production exceeding the demand, stocks at the pit-heads increased and, while prices fell, the increased cost of living prompted the miners to demand higher wages. British coal imported during the first nine months of 1924 amounted to 2,117,918 tons, and represented 30·4 per cent. of the total.

Notwithstanding the financial crisis the metallurgical and engineering industries are stated to be in a fairly prosperous condition. The pig-iron trade is steadily developing, the number of furnaces in blast having increased from 40 in December, 1923, to 47 in November 1924, the latter comparing favourably with the 1913 figure of 54. Production has not only increased by over 30 per cent. as compared with 1923, but, owing to modernisation of plant, exceeded the 1913 tonnage by a substantial margin. The production of finished steel shows a similar increase.

Proof that Great Britain is a large buyer of semi-finished and finished steel products forms a very striking feature of the report; in many cases this country heads the list of purchasers. To quote a few items, 317,288 tons of steel bars, representing roughly three-quarters of the total amount exported, were consigned to Great Britain. The total shipments of constructional steel amounted to 186,134 tons, of which 55,128 tons were brought to this country; in addition some 16,000 tons of rails and 43,000 tons of sheet-iron were exported to the United Kingdom. Again, the British demand for miscellaneous varieties of iron and steel bars and sheets increased from 139,865 tons in 1923 to 235,700 tons in 1924. In the steel import trade German competition with British products is making itself keenly felt, but

it is satisfactory to note that Great Britain practically monopolises the tin-plate market.

The position of the Belgian engineering industry is stated to be relatively satisfactory, and in spite of difficulties due to exchange questions, the shipments of machines and machine parts show an increase over the figure for 1923. The outlook in the glass, chemical and building material industries is favourable, business appears to be developing on normal lines and, with one or two exceptions, sales are steadily increasing. The export trade in fire-arms is fully maintained; a shortage of skilled labour, however, is a difficulty.

Improvements and extensions with a view to relieving traffic congestion on the railways are being vigorously pushed forward. Much work has been accomplished during the past year, not only in the laying of new track and the enlargement of premises but in the reorganisation of administration. An important programme of road improvements necessitated by motor traffic is also contemplated. The development of electric light and power continues at a rapid rate, and production is being concentrated in central power stations which are being continually enlarged. Work on harbour and dock extensions at Antwerp, Ghent, and Ostend is progressing and further enlargements are being discussed. The port of Brussels officially opened in 1922 is rapidly increasing in importance.

The most striking feature of industrial life in Belgium to-day is the movement towards the reduction of costs of production and the cutting-down of overhead charges. Output capacity is being increased by the installation of the most modern labour-saving machinery, and all possibilities of economy in working are being closely studied.

HELIUM - OXYGEN MIXTURES FOR THE MITIGATION OF CAISSON DISEASE.

IN continuing its researches on the safety of workers engaged in caisson work and in diving, the United States Bureau of Mines has been able to take up a line of experiments which, unfortunately, other countries will hardly be in a position to follow.

In this work mixtures of oxygen and helium have been used, the latter is a gas not at disposal for industrial purposes elsewhere. The reason for replacing the nitrogen of our atmosphere by helium in the caisson air is that helium is less soluble and more readily diffusible in water and the body fluids, and there is hence less danger during the decompression from the formation of large bubbles such as nitrogen would give. The decompression period is known to be more dangerous than the compression period.

With the improved apparatus now in use men may safely work in atmospheres at 25 and 30 lb. pressure per square inch. When the pressure is raised to 50 lb., the risk of caisson illness is much increased. In diving operations, however, depths of 200 ft., corresponding to pressures of 100 lb. are now risked. When the man descends, he may pass through 30 or 40 ft. in one minute; it is in fact desirable not to spend too much time on the descent, since the whole period is limited. The absorption of the gases by the blood causes no great inconvenience apart from ear trouble. It is during the decompression that the formation of gas bubbles takes place, which may be fatal. The time rate of ascending depends upon the air pressure to which the man has been exposed. A man may descend to 200 ft. in five or ten minutes; but after staying at the bottom for 45 minutes he would require two hours to accomplish his ascent in safety. Experiments made on behalf of the Bureau by R. R. Sayers, W. P. Yant and J. H. Hildebrand [Reports of Investigations, Serial No. 2670], with mixtures of either nitrogen or helium and oxygen, containing from 1 to 15 per cent. oxygen, show that the decompression period can be reduced, in the case of small animals, to one-sixth when helium is substituted for nitrogen. Similar reductions were found possible in the preliminary experiments made with men. The experiments are being continued by the Bureau of Mines in conjunction with the United States Navy.

INTERNAL-COMBUSTION AND STEAM ENGINES FOR HIGH-SPEED PASSENGER VESSELS.*

By SIR JOHN BILES, K.C.I.E., LL.D., D.Sc.

ON February 11 of this year, in this hall, one of our members, Sir Fortescue Flannery, read the following sentence of death on the steam engine: "He believed that the use of Diesel machinery for navigation would become so common that only for special purposes would the steam engine be able to hold its place." Lord Bearsted, the chairman at the meeting of the Royal Society of Arts, at which Sir Fortescue's paper was read, delivered the funeral oration, and Sir Robert Dixon, while excusing the Admiralty for continuing the use of a supposed dead instrument, pointed out that for some purposes, such as obtaining the highest speed in warships, there was still a flicker of life in the steam engine. In the face of so much discouragement it may seem to some that it is unnecessary to investigate the relative merits of these different methods of providing power to propel ships. It has, however, fallen to my lot to take part in such an investigation in connection with high-speed passenger ships.

One large passenger ship has been finished, and others are being completed, with Diesel engines of about 14,000 h.p. or more. Some of these are intended to obtain this power on two shafts and some on four. If the former are successful there will be no new experience in applying the same type of machinery to four shafts and so obtaining machinery of 28,000 h.p. or more. The engines of one of these ships have been tried at sea, and others that are building have been run successfully for days in the works in which they have been made. It will not be many months before the supreme test of running these high powers at sea will have been made, and if these trials are successful the upper limit of powers of Diesel engines will have been very much extended, and the Diesel will have become a direct rival to the steam engine for high-speed passenger ships. But it is premature to talk of the Diesel completely superseding the steam engine. The upper limit of power of the Diesel engine is much below the upper limit for the steam engine, so that at present there can be no supersession of machinery above the Diesel's upper limit of power. High-speed warships of all types cannot adopt the Diesel engine for this reason. Oil which has made the Diesel a possibility has much increased the output and the

* Paper read at the Spring Meetings of the Institution of Naval Architects in London, April 2, 1925.

ENGINES FOR HIGH-SPEED PASSENGER SHIPS.

Fig. 1. FOUR-SCREW FAIRFIELD-SULZER DIESEL INSTALLATION OF 24,000 S.H.P.

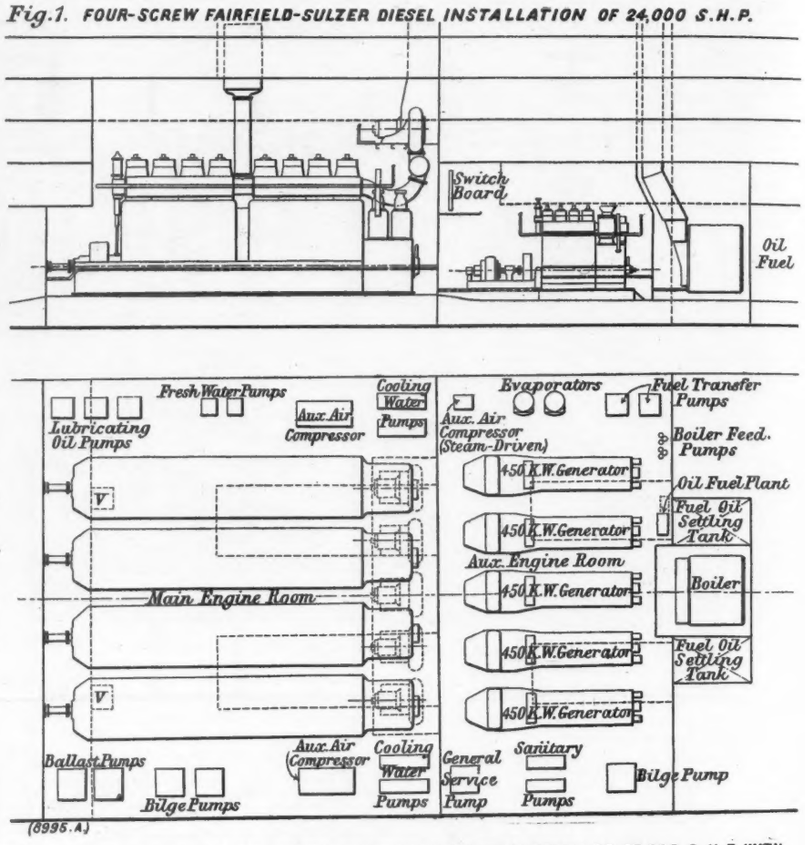
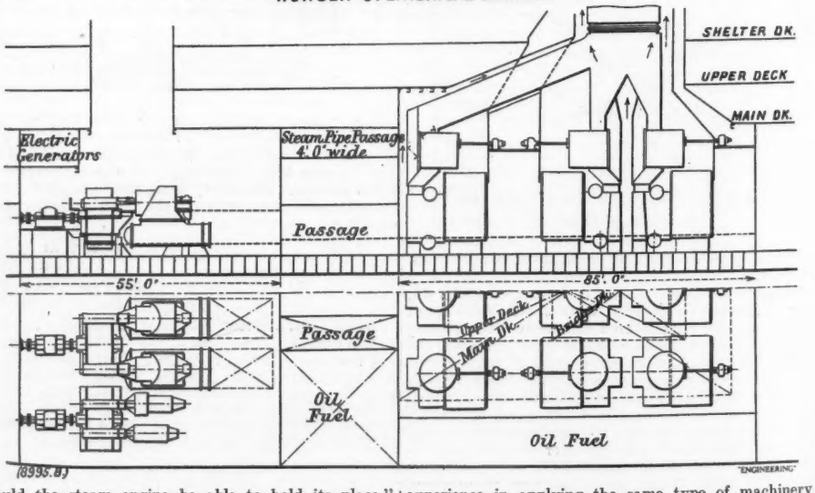


Fig. 2. FOUR-SCREW 265-LB. PRESSURE TURBINE INSTALLATION OF 27,000 S.H.P. WITH HOWDEN CYLINDRICAL BOILERS.



ENGINES FOR HIGH-SPEED PASSENGER SHIPS.

Fig. 3. TWIN-SCREW 500-LB. PRESSURE TURBINE INSTALLATION OF 27,000 S.H.P. WITH BABCOCK W.T. BOILERS.

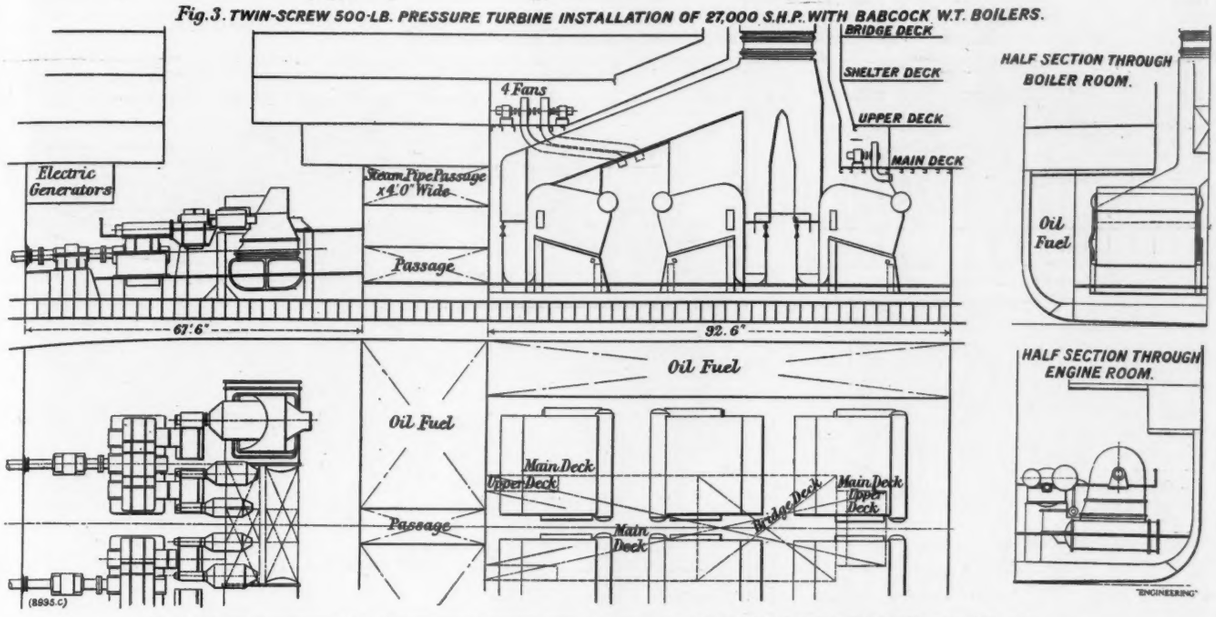
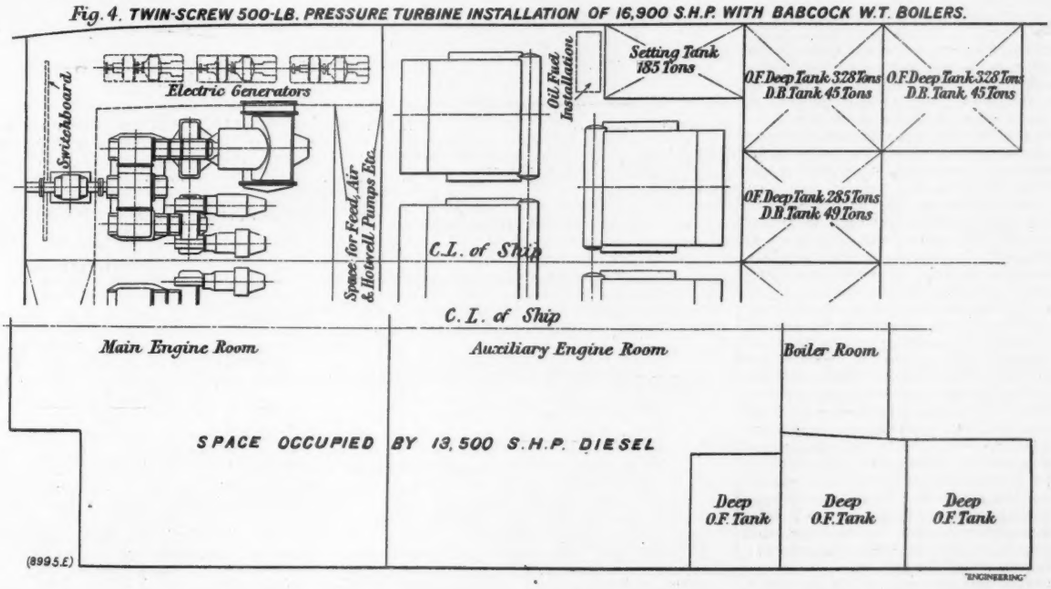
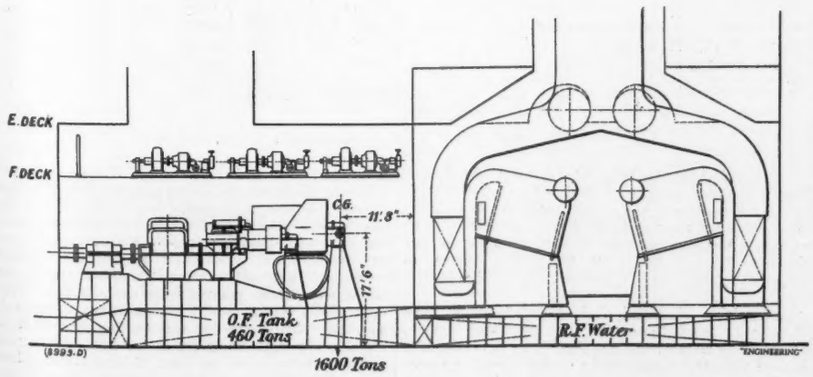


Fig. 4. TWIN-SCREW 500-LB. PRESSURE TURBINE INSTALLATION OF 16,900 S.H.P. WITH BABCOCK W.T. BOILERS.



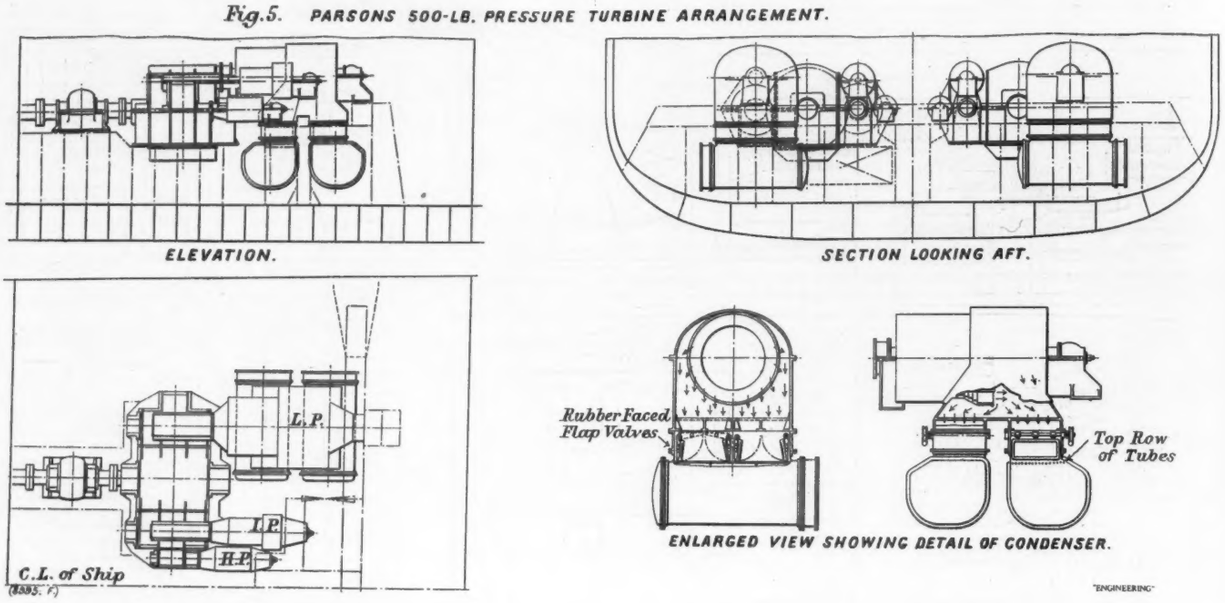


economy of the steam engine. The advantage of the Diesel over the steam engine is that the oil has been more efficiently used in the cylinders of the Diesel than in the furnaces of the boilers which supply the steam for the older type of machinery, and the steam so produced has not had the same range of temperatures to work in that the oil in the Diesel has had. But developments are taking place in the boilers and the steam turbines which promise to remove some of these differences in economic output. Sir Charles Parsons gave some figures in a paper read at the World Power Conference in July, 1924, in which he proposed steam turbines working at 500 lb. per square inch pressure and 700 deg. F. steam temperature driving propellers through reduction gearing, the steam being generated in water-tube boilers fitted with air pre-heaters. This system is hereafter referred to as the H.P.T. type. In the paper it is shown that an overall thermal efficiency may be obtained not much inferior to the best results secured by the Diesel. Statements of this kind from such a high authority lead to the conclusion that we can either by the steam or the Diesel engine obtain much more power per ton of fuel carried and used than can be got in existing steamships. The method of obtaining these results is explained in Appendix I.

Before we decide on the relative merits of steam and Diesel engines for ship propulsion we have to take into account: (*a*) the relative first cost; (*b*) the relative cost of Diesel and boiler fuel; and (*c*) the relative working costs, including crew and maintenance. The construction of Diesel engines of large powers has not been sufficiently stabilised or sufficiently extensive to make it possible to standardise the manufacture so as to ensure the lowest possible first

ENGINES FOR HIGH-SPEED PASSENGER SHIPS.

Fig. 5. PARSONS 500-LB. PRESSURE TURBINE ARRANGEMENT.



cost. The double-acting engine which promises to be the least costly to produce is more or less experimental, and under such circumstances is not likely to have reached the lowest possible cost of production. On the other hand, steam boilers and turbines have probably reached very nearly the highest economy of production costs, as they have been produced for many years and in large numbers. The relative cost of boiler and Diesel oil fuel suitable for ship propulsion seems to be a variable quantity. The difference in cost varies from nothing to 20 per cent. in favour of the boiler-fuel oil. There are some oils of about the same thermal efficiency which can be used in a boiler which cannot or have not been used in a Diesel engine, and even if they are used it has been estimated that the cost of the Diesel oil might be nearly 20 per cent. higher without being superseded by the oil suitable for a boiler. It seems probable that for some time to come the oil fuel for the steam engine will be cheaper than for the Diesel. The cost of the crew for the Diesel engine ship will most probably be less than for the turbine-driven ship in high-powered machinery, but for powers below 10,000 h.p. this does not seem to hold. As to the relative cost of maintenance and repair, it is too early to dogmatise. These costs in the case of the turbine and boilers are known and are not high. The number of moving parts of a Diesel engine is very large, and the liability to wear and damage is not small, but until the latest types have been run at sea for some time we must wait for full knowledge on this subject.

As far as can be judged from the data available it seems to be probable that the turbine will give results in commercial efficiency which will make it a strong competitor with the Diesel. It is, therefore, not the Diesel alone which will make existing steamers obsolete, but also developments in the steam engine itself are very likely to produce the same results. The gain in the Diesel over the steam engine is in the smaller consumption of oil per unit of power, but the cost and weight of the Diesel are much greater than the turbine installations using high-pressure steam in the way suggested by Sir Charles Parsons. Let us take the case of the latest and only Diesel ship of high speed, the Aorangi, which has been completed, and compare its performance with that of a steamship of about the same dimensions and power, built by the same firm—the Fairfield Company. It happens that this steamship is one of several of about the same size and power built at about the same time by the same and other firms, so that its name need not be stated. These steamships are all oil fired, with double-reduction turbines. The leading particulars of the two ships are given in Table I.

It is claimed for the Diesel engine in passenger ships that more space is available for passengers than in the steam ships. We may judge of this by observing the relative spaces occupied by machinery openings in the two cases. Several designs have been prepared

TABLE I.

	Diesel (*Aorangi*).	Steam.
Dimensions	580 ft. × 72 ft. × 46 ft. 7 in.	546 ft. × 70 ft. × 43 ft. 3 in.
	Sea. Measured Mile.	Sea. Measured Mile.
Draught, mean	26 ft. 5½ in.	24 ft. 10 in. 25 ft.
Shaft horse-power	12,200 12,400	12,050 13,885
Speed, knots	17·91 18·237	17·2 17·96
Displacement, tons	20,740	19,000 19,150
Consumption per shaft horse-power/hour, in lb.	0·395 for main engines 0·036 for auxiliary engines	
	0·431	0·984
Consumption of oil for 3,000 nautical miles (estimated from sea trial)	393 tons	923 tons
Estimated reserve feed water in 3,000 nautical miles	28 ,,	350 ,,
Total weight of oil and water used in 3,000 nautical miles	421 ,,	1,273 ,,
Mean gain in speed during voyage due to reduction in weight of fuel and oil on board	0·08 knot	0·23 knot
Equivalent difference in shaft horse-power during voyage if vessels run at same speed	1·4 per cent.	4 per cent.
Area on five decks due to machinery openings	about 14,000 sq. ft.	15,500 sq. ft.
Extra length of ship necessary to give same area of decks exclusive of machinery openings	—	4·2 ft.

TABLE II.

Type.	(*a*) Diesel.	(*b*) Steam.	(*c*) H.P.T.	(*a*) Diesel.	(*b*) Steam.	(*c*) H.P.T.	(*a*) Diesel.	(*c*) H.P.T.	(*c*) H.P.T.
Sea speed, knots	20	20	20	20	20	20	17	17	18
Fuel per shaft horse-power	0·5	1·0	0·7	0·5	1·0	0·7	0·5	0·7	0·7
Shaft horse-power	27,000	28,000	27,000	27,000	28,000	27,000	13,500	13,500	16,900
Distance in nautical miles	6,460	6,460	6,460	3,230	3,230	3,230	3,230	3,230	3,230
Weight of machinery	4,450	4,250	2,700	4,450	4,250	2,700	2,650	1,300	1,600
Weight of feed water	109	1,507	727	55	754	364	32	214	253
Weight of fuel	1,947	4,037	2,725	973	2,018	1,362	572	802	948
Weight of machinery, fuel and water	6,506	9,794	6,152	5,478	7,022	4,426	3,254	2,316	2,801
Weight of half fuel and water	1,028	2,772	1,726	514	1,386	863	302	508	600
Weight less half fuel and water	5,478	7,022	4,426	4,964	5,636	3,563	2,952	1,808	2,201
Gain over Diesel in weight of machinery, fuel and water	—	3,288 loss	354	—	1,544 loss	1,052	—	938	453
Gain over Diesel less half fuel and water	—	1,544 loss	1,052	—	672 loss	1,401	—	1,144	751

Note.—H.P.T. = high-pressure turbine.

for ships of different sizes and lengths of voyage. These are shown in Figs. 1 to 5. The types include (*a*) Diesel engines; (*b*) steam turbines of existing types of machinery and cylindrical tubular boilers; (*c*) steam turbines working at 500 lb. pressure and 700 deg. temperature from water-tube boilers as proposed by Sir Charles Parsons, called the H.P.T. type.

The weights of Diesel engines and those of type (*b*) are very much the same. The weight of type (*c*) is from 40 to 50 per cent. less than (*a*). It is generally claimed that the consumption of the Diesel is about 0·4 lb. per shaft horse-power for the main engines. It is also claimed that for all purposes in the Aorangi the consumption is 0·45 lb., the difference being due to the auxiliary purposes for which power and steam are used in the ship. The Aorangi has: Four generating sets, each of 300 kw., and an emergency dynamo, all driven by Diesel engines, two cylindrical boilers, oil-fired, supplying steam for oil-fuel burning installation, fuel-oil transfer and service pumps, piston-cooling water pump, auxiliary air compressor, feed pumps, air and circulating pumps for auxiliary condenser, general service, pump, ballast pump, forced lubrication pumps, fresh-water pumps, water-tight doors pump, and a steam-driven dynamo for port use, also steam for the heating system of the vessel. The amount of steam for auxiliary purposes naturally varies with the kind of auxiliary machinery and purposes to which fuel is applied. In a 20-knot turbine 20,000-ton passenger ship the amount of water evaporated per lb. of oil fuel was measured with the boilers at full power. An estimate of the fuel used for driving the auxiliaries in this ship is

THE THOMAS AVERAGING RECORDER FOR ELECTRIC POWER SUPPLY.

CONSTRUCTED BY MESSRS. ELLIOTT BROTHERS (LONDON), LIMITED, LEWISHAM, LONDON, S.E. 18.

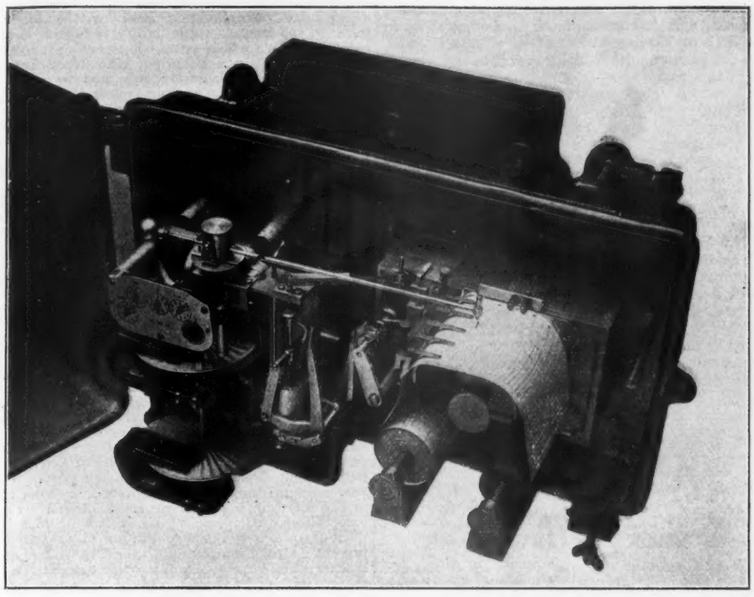


FIG. 1.

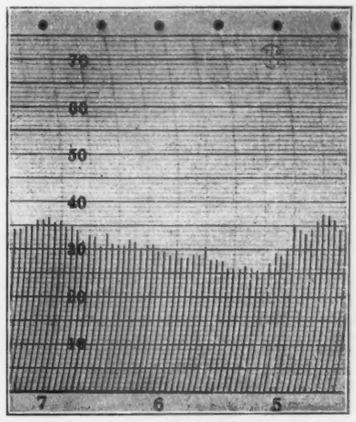


FIG. 2.

0·15 lb. of oil per hour per shaft horse-power of main engines, and an estimate of the fuel for auxiliaries in a 20,000-ton Diesel ship of 20 knots gives 0·107 lb. per shaft horse-power per hour as the consumption. In the case of the steam ship, steam is used only for feed, air, general service, and circulating pumps for main and auxiliary condensers, for cooking, evaporator, ship's heating, brine warming, hot salt and fresh-water calorifiers. If 0·45 lb. is used for Aorangi for all purposes it seems as if either the shaft horse-power at which the ship is running has been over-estimated, or that her auxiliaries are very much more efficient than in other ships. In comparing the Diesel (*a*) with (*b*) and (*c*), the following figures have been used for auxiliaries :—(*a*) 0·1 ; (*b*) 0·15 ; (*c*) 0·1. We may take the consumptions for main machinery as follows :—(*a*) 0·4 ; (*b*) 0·9 ; (*c*) 0·6. With sea water at 60 deg. and vacuum 28 in., the totals for all purposes will be :—(*a*) 0·5 ; (*b*) 1·05 ; (*c*) 0·7. (See Table II.)

Reserve Feed-water.—This item is considerable, and depends on the length of voyage and how much make-up feed is made by the evaporators. Some authorities have determined the amount of make-up feed required in cylindrical boilers in merchants ships to be 3½ tons per 1,000 h.p. per day. From observations in some recent passenger ships this amount of water is found to be as much as 4 tons, no evaporators being used. In Diesel ships the amount is small and may be taken at about 0·3 ton per 1,000 h.p. per day. This amount will be increased if fresh water is used in circulation for cooling parts of the engine. This large difference between the steam and Diesel engines can be reduced by the use of evaporators. In the steam system (*c*) it is assumed that 2 tons per 1,000 h.p. per day will be sufficient, together with evaporators capable of giving another 2 tons if required.

(*To be continued.*)

AVERAGING RECORDER FOR ELECTRIC POWER SUPPLY.

IN connection with the supply of electric power in bulk, it is necessary to know not only the total amount of energy supplied, but also the manner in which the demand fluctuates, since the efficient utilisation of the generating plant, and therefore the cost of production, is considerably affected by wide variations in the load. To encourage the consumer to keep the load as uniform as possible, the charges for bulk supply usually include a term proportional to the maximum demand, but for this to be equitably arranged between the parties concerned, it is obviously desirable to distinguish between a purely momentary maximum which can be dealt with by the "flywheel effect" of the installation, and one which is maintained for a considerable period, involving the bringing into service of additional plant.

Some difficulty has been experienced, hitherto, in the production of an instrument to give reliable information as to the magnitude and duration of the maximum demand in a simple and convenient manner which will be equally acceptable to the consumer and to the supply authority, but the one illustrated above appears adequately to meet the requirements of both parties. This instrument, which is known as the Thomas averaging recorder, is made by Messrs. Elliott Brothers (London), Limited, Century Works, Lewisham, S.E. 18, and is sold jointly by them and by Messrs. Siemens Brothers and Co., Limited, Woolwich, S.E.18, to whom we are indebted for the particulars given below.

Fig. 1 shows the instrument with the cover opened to expose the mechanism, on the left of which will be seen an ordinary integrating watt-hour meter of a type and capacity suitable for the supply system and for the load carried. The integrating mechanism is provided with an additional vertical spindle, the upper end of which carries a mild-steel disc on which rests a small permanent bar magnet. The arrangement, which constitutes a form of magnetic clutch, serves to rotate a horizontal balanced pen arm which is attached to the magnet, the pen moving over, but not in contact with, a paper chart. The latter is moved continuously by clockwork mechanism, and at the end of definite time intervals the clockwork releases a cam, allowing a glass disc to rotate until a pair of fingers come into contact through a gap in the glass. This energises an electro-magnet which pulls down the marking point of the pen into contact with the paper chart. Immediately afterwards, an arm fitted with a flexible end piece and operated by the same electro-magnet returns the pen point to the zero of the scale on the chart, so that an arc is drawn on the paper, the length of the arc corresponding to the energy consumption over the period during which the pen arm has been connected with the integrating mechanism. When the pen arm reaches the zero position, the electro-magnet is de-energised, so allowing the pen to lift clear of the paper, and, at the same time, the flexible-ended arm returns to its original position, so enabling the pen arm to be moved forward again by the integrating mechanism. It should, perhaps, be pointed out that the magnetic connection between the pen arm and the steel disc of the integrating mechanism is a very light one, and the fact that the latter is driven by worm gearing prevents the total reading of the meter from being affected by the action of pulling back the pen arm. Any retarding effect due to pen friction is, of course, avoided since the pen is clear of the paper while it is being moved forward.

By the repetition of the operations above described, a diagram of the form illustrated in Fig. 2 is produced, the record being equal in accuracy to that of the integrating meter. The particular diagram reproduced represents the output of the Carville Power Station B of the Newcastle-upon-Tyne Electric Supply Company, Limited, for a period of about 2½ hours. The maximum demand, in this case, was 37,000 kw., this load having been carried for a period of three minutes, represented by the space between each pair of lines on the diagram. The upper ends of the lines, it will be noticed, are sufficiently close together to form a curve of maximum demand over the whole period that the instrument is in use. The charts, it should be mentioned, are 65 ft. in length, and when the standard time interval of 15 minutes is used, the paper is fed forward at the rate of ½ in. per hour, so that one chart covers a period of 60 days. Time intervals ranging from 2 minutes to 60 minutes can, however, be used if required, with corresponding alterations in the rate of paper feed. The pens, which are of the spring-stylographic type, are provided with large ink reservoirs, so that the recorder can run for long periods without attention.

THE ANALYSIS OF FUEL GASES.

SEVERAL methods are available for the analysis of fuel gases and the control of the working of gas retorts, gas producers, and coke ovens. Fractionated condensation at low temperatures is convenient for the estimation of moisture, carbon dioxide, ethylene, benzene, &c., and for their separation from the more permanent gases ; but the method is not expeditious, and few laboratories command the required gas liquefaction plant. Optical methods, depending upon the determination of the refractive index, are not reliable because the differences in the refractive powers of the various gases are small. Combustion methods are mainly applied in the ultimate analysis, but they are also combined with the most commonly adopted determination, the absorption method. The absorbed constituents may afterwards be estimated by volume difference or by titration and analysis. It is essential that the right order of absorption is observed ; for many absorbents will take up several of the constituents to be determined, and in this and other respects the various instruments differ.

The apparatus which Professor S. W. Parr and Mr. F. E. Vandaveer recommend in Circular No. 12 of the Engineering Experimental Station of the University of Illinois, under the name of Illinois apparatus, is described as a modified Orsat apparatus. But it bears little resemblance to the original Orsat, which has undergone many modifications, coupled with various names. In the Illinois apparatus the several absorption pipettes are replaced by an absorption burette of the Morehead type, which can be charged with several liquids and serves also as measuring burette. It is a high burette jacketed with acidulated water. The apparatus is combined with a copper oxide furnace, heated by a chromel wire coil, and a slow-combustion pipette containing a platinum spiral. To start the work the furnace is heated up to 300 deg. C., and the several parts are flushed with nitrogen. A sample of 100 cub. cm.

is then drawn into the burette. The order of absorption is: carbon dioxide (absorbed by caustic soda), illuminants (by bromine water), oxygen (by alkaline pyrogallate), and carbon monoxide (by acid cuprous chloride). There remain hydrogen (which is burnt in the furnace with oxygen), methane and ethane (burnt in the combustion pipette), and finally nitrogen, which is still merely determined by difference, so that a real check on the results of the analysis is not possible. The circular mentioned does not refer to the instruments which depend upon the heating of fine platinum wires and upon the rate of cooling of hot wires in atmospheres of different gases, the katarometers of the Cambridge Instrument Company, and the cognate apparatus of the Siemens-Schuckertwerke which, originally indicators, have been perfected into recording measuring instruments.

P. AND O. LINERS "RAWALPINDI" AND "RANPURA."

ON March 26, Messrs. Harland and Wolff, Limited, launched at Greenock, the twin-screw mail and passenger liner Rawalpindi which is being constructed to the order of the Peninsular and Oriental Steam Navigation Company. The vessel is 570 ft. long, 71 ft. broad, and 47 ft. 6 in. deep, with a straight stem and cruiser stern, and has a gross tonnage of 16,000. Twelve watertight bulkheads extend to the shelter deck. These divide the vessel below the main deck into seven cargo spaces, cross bunker, two boiler rooms, engine room and fore and after peaks. A double bottom extends right fore and aft and is partitioned for the carriage of oil fuel, fresh water, and water ballast. The propelling machinery, which has been constructed at the builders' works at Belfast, will be fitted on board at that port, and consists of two sets of balanced quadruple expansion engines of some 15,000 i.h.p. Steam will be supplied at 215 lb. per square inch pressure by six double-ended cylindrical boilers operating under forced draught and arranged for burning oil fuel.

A second vessel of somewhat similar dimensions, equipment and tonnage, the twin-screw steamship Ranpura, built and engined by Messrs. R. and W. Hawthorn, Leslie and Co., Limited, at the Hebburn shipyard for the P. and O. Company, recently completed satisfactory trials in the North Sea, attaining a mean speed of 17¾ knots.

LETTER TO THE EDITOR.

NICKEL-COPPER ALLOYS.

TO THE EDITOR OF ENGINEERING.

SIR,—We notice on page 341 of your issue of March 20, that Mr. A. J. G. Smout is reported to have stated at the meeting of the Institute of Metals that "The elastic limit of the nickel-copper alloy remained unchanged up to a temperature of 300 deg. C., whilst with Delta metal containing 2 per cent. of nickel there was a fall of 60 per cent. at this temperature."

As "Delta" is our registered trade mark and we sell a vast number of metals, alloys and articles under this mark, differentiating between such alloys, metals and articles by such terms as "Delta" Bronze No. IV; "Delta" silver bronze; "Delta" copper; and "Delta" stampings, &c., it would be more illuminating if Mr. Smout stated to what particular commodity, sold by us, he referred, as in its present use by Mr. Smout the term is distinctly misleading.

Perhaps you would kindly give publicity to these remarks so that it may dispel any possible misapprehension that the report appearing in your paper may have caused in the minds of your readers.

Thanking you in anticipation.

We, are, yours faithfully,
For the DELTA METAL COMPANY, LIMITED.
A. F. H. DICK, Managing Director.

East Greenwich, March 27, 1925.

TO THE EDITOR OF ENGINEERING.

SIR,—In reply to Mr. Dick's comments on certain of my remarks made at the annual meeting of the Institute of Metals, it will, of course, be understood that no disparagement was intended on any of the products of the Delta Metal Company; I was simply stating a scientific fact and comparing the effect of adding 2 per cent. nickel to copper with the effect produced by the addition of 2 per cent. nickel on that group of alloys containing approximately 57 per cent. to 58 per cent. copper, which are commonly known as delta metal.

The basis of my remarks was founded on a curve published in a paper read before the American Society of Mechanical Engineers in May, 1924, by Messrs. Upthegrove and White, in which these gentlemen gave a synopsis of available data on the properties of non-ferrous metals and alloys at various temperatures. In Fig. 21 of this paper these gentlemen, utilising data obtained from the work of Professor F. C. Lea, late of Birmingham University (*cp.* ENGINEERING, August 27, 1920), show that delta metal containing 2 per cent. nickel has an elastic limit at 300 deg. C. equal to approximately 40 per cent. of that possessed at atmospheric temperature, whereas nickel copper containing 2 per cent. nickel shows little or no falling away in elastic limit at 300 deg. C.

The composition of the delta metal in question is given in this paper as:—

	Per cent.
Copper	58·27
Iron	0·13
Nickel	2·2
Lead	0·15
Zinc	39·05
Tin	0·06
Manganese	0·14

Had Mr. Dick been at the meeting in question he would have realised, I think, that the main object of my remarks was to put forth a plea for the testing of the alloy under discussion at temperatures approaching those met with in actual practice, rather than, as is so frequently done, pinning one's faith to the results obtained at normal temperatures.

I cited another alloy by way of contrast, as showing the way in which some metals and alloys fall away in mechanical strength at slightly elevated temperatures—a fact which is, of course, well known and allowed for by engineers.

Yours faithfully,
ARTHUR J. G. SMOUT.

Moseley, Birmingham, March 31, 1925.

BOOKS RECEIVED.

Schlomann-Oldenbourg Illustrated Technical Dictionaries in Six Languages. English, German, Russian, French, Italian, Spanish. Vol. XV., *Spinning. Its Processes and Products.* Edited by ALFRED SCHLOMANN. London: Lewenz and Wilkinson, Limited. [Price 41*s.* net.]

Einfluss der Flichkräfte auf Eisenbahnbrücken. By Dr. Ing. O. KOMMERELL and BRUNO SCHULZ. Berlin: Wilhelm Ernst and Sohn. [Price 2·10 marks.]

Motor Manuals. Vol. II. *Carburettors and Carburation. The Theory, Application, Construction, Fitting, Testing, Tuning and Maintenance of Carburettors.* By ARTHUR W. JUDGE. London: Chapman and Hall, Limited. [Price 4*s.* net.]

Elektrochemie und ihre physikalisch-chemischen Grundlagen. II. *Experimentelle Elektrochemie.* By Dr. HEINRICH DANNEEL. Berlin and Leipzig: Walter de Gruyter and Co. [Price 1·25 marks.]

United States Bureau of Mines. Technical Paper No. 352. *Detection of Small Quantities of Petroleum Vapor with the Burrell Methane Indicator.* By G. W. JONES and W. P. YANT. [Price 5 cents.] No. 359. *The Purification of Copper Sulphate Solutions.* By G. S. TILLEY and O. C. RALSTON. [Price 10 cents.] Washington: Government Printing Office.

The Art of Town Planning. By H. V. LANCHESTER, F.R.I.B.A. London: Chapman and Hall, Limited. [Price 21*s.* net.]

The Management of Marine Engines and Boilers. By ERIC PRINCE. London: Scott Greenwood and Son. [Price 10*s.* 6*d.* net.]

Department of Commerce. Bureau of Foreign and Domestic Commerce. Statistical Abstract of the United States, 1923. Washington: Government Printing Office. [Price 85 cents.]

The Mechanical Investigations of Leonardo da Vinci. By IVOR B. HART, B.Sc., Ph. D.. London: Chapman and Hall, Limited. [Price 16*s.* net.]

The Modern Soap and Detergent Industry. Including Glycerol Manufacture. Vol. II. *The Manufacture of Special Soaps and Detergent Compositions.* By GEOFFREY MARTIN, D.Sc., Ph.D., F.I.C. London: Crosby Lockwood and Son. [Price 36*s.* net.]

The Metal Workers' Practical Calculator, for Blacksmiths, Forgers and Ironworkers, &c. By J. MATHESON. London: Sir Isaac Pitman and Sons, Limited. [Price 2*s.* net.]

Practical Advice to Inventors and Patentees. Inventions and How to Patent Them. By C. M. LINLEY. London. Sir Isaac Pitman and Sons, Limited. [Price 3*s.* 6*d.* net.]

The Soap and Water Missionary. By G. W. SHIPWAY. London: Arthur H. Stockwell. [Price 2*s.* net.]

Das Fernsprechwesen. I. Grundlagen und Einzelapparate der Fernsprechtechnik. By W. WINKELMANN. Berlin and Leipzig: Walter de Gruyter and Co. [Price 1.25 marks.]

TENDERS.—It is announced by the Department of Overseas Trade, of 35, Old Queen-street, London, S.W.1, that the Siamese State Railway Authorities invite tenders for the supply of material for railway construction. Such material includes angles, washer-plates, angle knees, and brackets, bolts and nuts, screws, &c., door fittings, galvanised corrugated sheets and cast-iron lamp-brackets. Tenders will be received by the Commissioner General, Royal State Railways at Siam, Bangkok, up to June 29, 1925. Copies of the specifications may be obtained at a cost of 30*s.* from Messrs. C. P. Sandberg, of 40, Grosvenor Gardens, London, S.W.1.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The Australian cruiser orders will provide employment at Sheffield in directions where it is most needed. The manufacture of forgings and castings and of machinery parts for assembly at Clydebank will furnish something like two years' work for several departments. Shipbuilding steel at the moment is much in the dumps, and according to leading employers requires every possible assistance to enable it to weather current depression. Some of the least pessimistic among local manufacturers subscribe to the opinion that no considerable improvement is likely so long as foreign rivals are in a position to underquote. The lower wages and longer hours of work ruling on the Continent are said to account for 90 per cent. of the present disparity in cost of production. The troubles of armament makers are again attracting widespread attention. British Admiralty work during the past twelve months has been quite insufficient to keep employed highly expensive organisations representing huge capital outlay and covering a wide area. Addressing the shareholders of Messrs. Cammell Laird and Co., Mr. W. L. Hichens, said the time had come when the Government should decide upon a definite policy in this connection. If it could be said with certainty that the day of armaments had gone never to return, it would (he declared) be wise policy to scrap existing plants. But while the future was uncertain the Government should make some provision for maintaining such plants.

Output of mild steel has been restricted by over two thousand tons per week since the end of January without producing any appreciable improvement. The big plants situated in Sheffield and district are functioning at not much more than one-quarter capacity. Many former buyers of this class of steel are working largely on cheap imported material. Reduced activity is also reported in wire rods and cold-rolled strip. A cut of 30*s.* per ton is announced in thin rods in order to bring prices more into line with those offered by foreign competitors. Alloy steel from Czecho-Slovakia is being offered to former Sheffield customers at prices which present a strong temptation to those in need of supplies. Makers of stove grates and light iron work are able to report fair order books, chiefly in connection with Corporation housing schemes.

South Yorkshire Coal Trade.—In face of persistent competition from the Continent, the volume of export business in best steam hards continues to be on the downgrade, and with the home demand only at a moderate level, the colliery position is anything but satisfactory. Cobbles and nuts are quotably unchanged, but business is sluggish and supplies can readily be obtained at attractive rates on the open market. Inferior slacks have weakened. Business in house coal is again dull, with the outlook uncertain. Quotations: Best branch hand-picked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 28*s.*; Derbyshire best brights, 26*s.* to 31*s.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 20*s.* to 24*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire hards, 18*s.* to 22*s.*; Derbyshire hards, 18*s.* 6*d.* to 22*s.*; rough slacks, 10*s.* to 12*s.* 6*d.*; nutty slacks, 8*s.* 6*d.* to 10*s.*; smalls, 4*s.* to 6*s.* 6*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Cleveland pig-iron, though somewhat scarce, is easy in price. Makers have sold fairly well, one prominent firm having disposed of their output to the end of June. Others, however, are less favourably placed, and there are merchants with parcels of iron to offer. Home demand continues to fall a good deal below what could be wished and inquiries from abroad show little improvement. Producers still ask up to 78*s.* for No. 3, but buyers state they experience no difficulty in placing orders for the ruling quality at 77*s.* 6*d.*; No. 1 is 82*s.* 6*d.*; No. 4 foundry, 76*s.* 6*d.*; and No. 4 forge, 75*s.* 6*d.*

Hematite.—East-Coast hematite is abundant. Makers have heavy stocks and are keen to negotiate for orders with the result that, notwithstanding prospects of substantial curtailment of output, values continue on the downward curve. In this branch also home and export demand are nothing like what was predicted early in the year. Nos. 1, 2 and 3 are offered at 83*s.* and No. 1 is quoted 83*s.* 6*d.*

Foreign Ore.—Business in imported ore is unheard of, and it is difficult to ascertain on what terms contracts might be arranged. In the continued absence of transactions, sellers keep quotations nominally on the basis of best rubio at 22*s.* c.i.f. Tees.

Blastfurnace Coke.—Durham blastfurnace coke is in very ample supply, and is little sought after. Good medium qualities are 22*s.* 6*d.* to 23*s.* delivered to local users.

Manufactured Iron and Steel.—Unsatisfactory accounts are given of nearly all departments of finished iron and steel. Several firms are keeping plant in operation only by work that comes forward from week to week. The 7*s.* 6*d.* reduction in shipbuilding material quotations was not unexpected, and it has failed to tempt buyers into the market.

It is gratifying to be able to report continued activity in galvanised sheets, and a rise of 5*s.* Common iron bars are 12*l.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 10*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel strip, bridge and tank-plates,

8*l.* 17*s.* 6*d.*; steel angles, 8*l.* 12*s.* 6*d.*; steel joists, 8*l.* 12*s.* 6*d.*; heavy steel rails, 9*l.*; and galvanised corrugated sheets (No. 24 gauge, in bundles), 16*l.* 15*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Quietness is still prevalent in the Scottish steel trade, and producers report a very poor demand all round. The amount of plant out of operation is exceedingly large, and there seems little prospect of this state of things altering for the better in the immediate future, as there are few inquiries of note in the market. Shipbuilding material is not getting a good outlet at present, as so many of the yards are quiet, and also because of imports from the Continent at cheap prices. Local producers are also feeling the pinch in the export markets, where Continental stuff is being delivered at much lower rates than the home maker can possibly accept. In the black sheet trade there is still quite a lot of business passing, although the margin is not very satisfactory. Galvanised sorts are doing very well and fairly heavy bookings are general, while foreign inquiries are again much better and prices have a firmer tendency. Since the last reduction in prices in the autumn, when 10*s.* per ton was taken off, the official quotations have not been altered, but availing themselves of the latitude allowed by the arrangements in the trade, quite a lot of business was accepted by makers at less than the list prices. Now, however, it has been arranged to bring these more into line, and the Scottish steelmakers have decided to reduce the official prices of ship plates and sections by 5*s.* per ton, for the home trade. No change has been made in boiler plates. The following are now the current quotations:—Boiler plates, 13*l.* per ton; ship plates, $\frac{3}{8}$ in. and up, 9*l.* 10*s.* per ton; sections, 9*l.* 5*s.* per ton; and sheets, $\frac{3}{16}$ in. to $\frac{1}{8}$ in., 11*l.* per ton. All delivered Glasgow stations.

Malleable Iron Trade.—The conditions in the West of Scotland malleable iron trade show no improvement, and the outlook is not satisfactory. With the demand continuing of a hand-to-mouth character running difficulties are not decreasing. The steel re-rolling branches are the best side of the works at the moment, and account for any activity which exists. Export business is quiet. Prices are nominally unchanged with "Crown" bars quoted at 12*l.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—A dull tone continues in the Scottish pig-iron trade and sales are difficult to effect. There is an undoubted lack of demand both for the home market and for shipment, and stocks are assuredly increasing on all hands. This is affecting prices, and in order to reduce losses production is likely to be further curtailed before long. The current quotations are:—Hematite, 4*l.* 11*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No. 1, 4*l.* 10*s.* 6*d.* per ton; and No. 3, 4*l.* 8*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipment of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, March 28, amounted to 534 tons. Of that total, 339 tons went overseas and 195 tons coastwise. For the corresponding week of last year the figures were 3,240 tons foreign and 90 tons coastwise, making a total shipment of 3,330 tons.

Wages in the Iron Trade.—The following intimation has been made to Messrs. James C. Bishop and Owen Coyle, joint secretaries of the Scottish Manufactured Iron Trade Conciliation and Arbitration Board, by Sir John M. MacLeod, Bt., C.A., Glasgow:—"In terms of the remit, I have examined the employers' books for January and February, 1925, and I certify that the average net selling price brought out is 12*l.* 6*s.* 8·25*d.*" This means no change in the wages of the workmen.

Shipbuilding.—The past month has been one of some activity in the shipyards, in a launching sense only, however, as the tonnage shows, and the Scottish output of 36 vessels, with a total of 77,660 tons, constitutes a record for the month of March. These figures do not, unfortunately, mean that the industry is busy, and to those who know the true state of things it means that the position is becoming more serious, as the amount of work now on the books is very much smaller. Nothing but an early revival in demand on the part of owners can save the industry from an extremely serious condition in the near future. Certainly something like a score of new vessels were contracted for during the past month, but while that is satisfactory, several times that number could be laid down almost immediately, as many yards have very little work on hand. To-day's costs are much too high, and owners cannot look at them, and until they become more moderate it is doubtful if the industry can recover much. The total output from all Scottish districts for the first quarter of the year is 62 vessels of 156,342 tons.

THE INSTITUTION OF METALS.—On April 22 an election of new members and students of the Institute of Metals will take place particulars of which can be obtained from the Secretary, at 36, Victoria-street, London, S.W.1. The election has been arranged in connection with the 15th Annual May Lecture to be given by Professor H. A. Lorentz, of Leiden, Holland, on May 6. The subject of the discourse will be "The Motion of Electricity in Metals," and tickets of admission to this lecture may be had from the Secretary of the Institute.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-night at 7 p.m., at Storey's-gate, S.W.1. Informal Meeting. Discussion on "Modern Developments of Gas Production."

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night, at 7.30 p.m., at 39, Victoria-street, S.W.1. Lecturette, "Engineering Contracts," by Mr. Geoffrey W. Tookey.

THE INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, April 4, at 3 p.m., at the College of Technology, Manchester. Annual General Meeting. "The Microscope as a Foundry Adjunct," by Mr. J. S. G. Primrose.

THE INSTITUTE OF TRANSPORT.—Monday, April 6, at 5.30 p.m., at the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. "The Lessons of the Indian Flight," by Air Vice-Marshal Sir W. Sefton Brancker, K.C.B., A.F.C.

THE SOCIETY OF ENGINEERS.—Monday, April 6, at 5.30 p.m., at the Geological Society, Burlington House, Piccadilly, W.1. "Problems in Designing and Constructing Sea Defence Works," by Mr. E. R. Matthews, M.Inst.C.E., F.G.S.

THE INSTITUTE OF TRANSPORT: YORKSHIRE SECTION.—Monday, April 6, at 5.30 p.m., at the Town Hall, Leeds. Lecture, "Air Transport," by Colonel Edwards.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Monday, April 6, at 7 p.m., at Savoy-place, Victoria-embankment, W.C.2. Informal Meeting. Discussion on "Insulation Problems in High-Voltage Engineering," opened by Mr. A. Collins.

THE INSTITUTION OF THE RUBBER INDUSTRY.—Monday, April 6, at 8 p.m., at the Engineers' Club, Coventry-street, W.1. "Notes from a Pioneer on Indian Rubber from the Latex," by Sir Henry Wickham. "Standardised Rubberware," by Mr. Fordyce Jones.

THE SURVEYORS' INSTITUTION.—Monday, April 6, at 8 p.m., at Great George-street, S.W.1. "The Law of Evidence," by Major H. F. Bidder.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, April 7, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C.2. "Vapour Pressures of Binary and Ternary Fuel Mixtures," by Mr. J. Stanley Lewis, B.Sc.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 7, at 6 p.m., at Great George-street, S.W.1. Ordinary Meeting. Papers to be submitted for discussion. "Bristol Waterworks: Cheddar Supply," by Mr. Alexander McCulloch Paterson, M.Inst.C.E. "The Water Supply of the City of Aberdeen," by Mr. George Mitchell, M.Inst.C.E.

THE INSTITUTION OF MECHANICAL ENGINEERS: SOUTH WALES BRANCH.—Tuesday, April 7, at 6 p.m., at the Chamber of Commerce, Swansea. "Powdered Fuel and its Relation to Modern Power Plant Design," by Mr. David Wilson.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, April 7, at 6.30 p.m., at 85-88, The Minories, Tower-hill, E.1. "Steering of Ships." by Capt. P. T. Brown and Mr. M. M. Parker, B.Sc.

THE INSTITUTION OF AUTOMOBILE ENGINEERS: COVENTRY CENTRE.—Tuesday, April 7, at 7.15 p.m., at the Broadgate Café, Broadgate, Coventry. "Brakes for Motor Vehicles," by Mr. Geo. W. Watson.

THE WEST YORKSHIRE METALLURGICAL SOCIETY.—Tuesday, April 7, at 7.30 p.m., at the George Hotel, Huddersfield. Discussion on "The Selection of Iron by Fracture and Chemical Analysis."

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, April 7, at 7.30 p.m., at 39, Elmbank-crescent, Glasgow. "Canadian Bulk Cargo Vessels on the Great Lakes," by Mr. William I. Hay and Mr. Duncan McArthur.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH BRANCH.—Tuesday, April 7, at 7.30 p.m., at 207, Bath-street, Glasgow. "The Economic Aspect of the Utilisation of Permanent Magnets in Electrical Apparatus," by Mr. E. A. Watson.

THE SOCIETY OF CHEMICAL INDUSTRY: CHEMICAL ENGINEERING GROUP.—Tuesday, April 7, at 7.30 p.m., at the White Horse Hotel, Congreve-street, Birmingham. Joint Meeting with the Birmingham Section of the Society of Chemical Industry. Subject for discussion: "Hand *v.* Mechanical Burners for Sulphur-Containing Materials." "The Combustion of Sulphur-Containing Materials in Hand and Mechanical Burners," by Mr. P. Parrish, A.I.C. "Notes on Mechanical Burners," by Mr. J. Harris. "The Design and Working of Burners for Sulphur Materials," by Mr. G. A. Smy.

THE RADIO SOCIETY OF GREAT BRITAIN.—Wednesday, April 8, at 6 p.m., at the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Informal Meeting. "Home-made Wireless Components and Sets," by Mr. E. C. Atkinson.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS.—Wednesday, April 8, at 6.30 p.m., at the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. "Some Recent Developments in A.C. Track Circuits," by Mr. R. Dell.

THE INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—Wednesday, April 8, at 7.30 p.m., at the Royal Victoria Hotel, Sheffield. "The Design of a Ferro-Concrete Retaining Wall for a Highway Improvement; with Notes on Reinforced Concrete Construction." by Mr. Edric Tasker.

THE INSTITUTION OF AUTOMOBILE ENGINEERS: WOLVERHAMPTON CENTRE.—Wednesday, April 8, at 7.30 p.m., at the Engineering and Scientific Club, Queen street, Wolverhampton. "Brakes for Motor Vehicles," by Mr. Geo. W. Watson.

THE INSTITUTION OF MECHANICAL ENGINEERS: GLASGOW AND WEST OF SCOTLAND BRANCH.—Thursday, April 9, at 7.30 p.m., at the Royal Technical College, Glasgow. "The Effect of Low and High Temperature on Materials," by Professor F. C. Lea, D.Sc.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Oil v. Coal for Ships.—Sir Wm. Seager, head of the Tempus Shipping Company, Limited, was yesterday elected president of the Cardiff Chamber of Commerce for the ensuing year, in succession to the Earl of Plymouth. In his presidential address Sir William made some interesting and important remarks in connection with the substitution of oil for coal as a motive power for ships. This question, he said, had been causing him considerable and anxious thought for the past three years. There was no doubt that steamers running between ports where cheap oil was available found its use an advantage, but he was of the opinion that for the ordinary tramp steamer the motive power would be coal for some years to come. If that were not so the population of this country would be placed in a very serious position, for coal in its raw state, as well as in the shape of manufactured goods, was about the only commodity we had to give in exchange for the foods we were bound to import from abroad. The supply of coal was practically inexhaustible. Nearly every country in the world had its own coal beds of varying quality, and new fields were being discovered constantly. There was, therefore, no fear of a shortage in the supply for hundreds of years. Probably also, at no distant date, coal would be treated scientifically in order to produce motive power in a form more easily handled than raw coal. The respective values of coal and oil were in the proportion of three to one—that is, 1 ton of oil was equivalent to 3 tons of coal. The main factor governing the consumption of both was the cost of the raw material, but other things had to be considered such as the handling on board, &c. It was doubtful if coal at its present price could compete with oil, but there must be a change, and coal would have to be produced at a lower figure, otherwise the industry would cease to function. Coal could and must, in the immediate future, be produced at a smaller cost than at present. If the cost of oil were 75*s.* per ton, then 3 tons of coal must be obtainable at a cheaper price than that.

The Coal Trade.—During the past week Welsh colliery owners secured an important contract from the Egyptian State Railways, successfully tendering for the supply of 150,000 metrical tons of large coal, which is to be delivered at Alexandria over the three months May, June, and July. The contract was obtained by Messrs. Watts, Watts and Co., who control the United National Collieries, Limited, and Messrs. Burnyeat, Brown and Co., Limited, at 34*s.* 6*d.* c.i.f. Alexandria, which figure is subject to certain deductions. Meantime the market, as is usual before a holiday, is a little more active with prices steadier.

THE LATE MR. T. J. REYNOLDS.—By the death, on March 23, of Mr. T. J. Reynolds, the British Thomson-Houston Company have lost an engineer who for the past 22 years has been associated with their turbine department, and who for long had been in charge of the installation of all turbo-generator plant on behalf of the company. The second son of the late Major T. W. Reynolds, R.A.S.C., he was born at Aldershot on December 8, 1876. The deceased gentleman was trained in the steam and mechanical engineering departments of Messrs. Combe, Barbour and Combe, Limited, of Belfast, and after spending many years in the Merchant Service with the P. and O. Steam Navigation Company and the Ocean Steam Ship Company, he joined the constructional staff of the B.T.H. Company, being placed in charge of his department in 1913.

CONTRACTS.—An order for the supply and erection of a hydraulic accumulator of 18 in. diameter and 20 ft. in length, for service at the Barry Port Workshops, Great Western Railway Company, has been secured by Messrs. Hollings and Guest, Limited, engineers, Thimble Mill-lane, Birmingham.—Messrs. Johnson and Phillips, Limited, cable makers and engineers, of Charlton, London, S.E.7, have secured a contract from the Central Argentine Railway Administration for some one million yards of special cable for use in connection with the electro-pneumatic signalling system being installed on that railway.—The Wiltshire County Council have placed an order with Messrs. John I. Thornycroft and Co., Limited, of Smith-square, London, S.W.1, for twelve 2½-ton hydraulically-operated tipping wagons—Messrs. Day, Summers and Co., Limited, of Northern Iron Works, Southampton, are undertaking the conversion to electric drive of the 1,500-ton steam hauling-up slipway supplied by them in 1907 to The Atlantic Coaling Company, Limited, of 36, Leadenhall-street, London, E.C.3.—We are asked to state, in connection with a reference in our issue of March 6 (page 298), to contracts placed in connection with plant for the Poplar Power Station, that the main contractors for this are Messrs. Vickers and International Combustion Engineering, Limited, Kingsway, W.C.2, the order placed with the Bradley Pulveriser Company, 37, Walbrook, E.C.4 being a sub-contract.

TURBINE-DRIVEN PUMPING PLANT FOR THE RAND WATER BOARD.

CONSTRUCTED BY MESSRS. W. H. ALLEN, SONS AND CO., LIMITED, ENGINEERS, BEDFORD.

(*For Description, see Page* 412.)

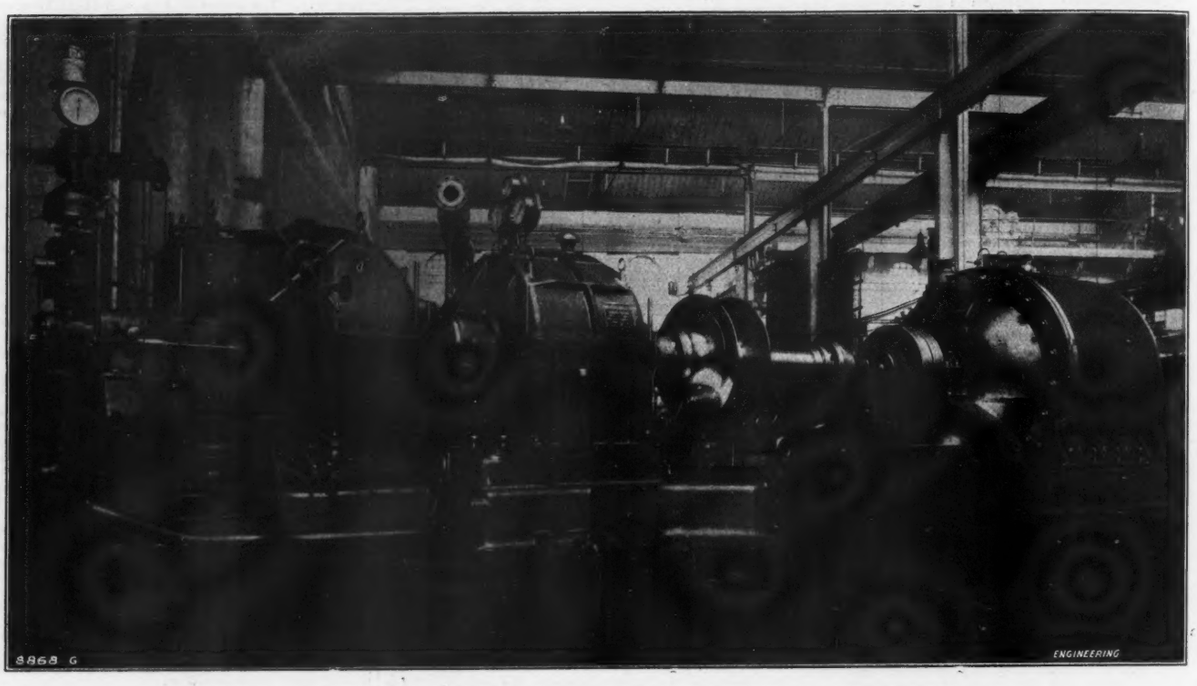


FIG. 16. STEAM TURBINE SET AS ERECTED FOR TEST, WITH DYNAMOMETER, AT THE BUILDERS' WORKS.

FIG. 17. 350-K.W. GEARED TURBO-ALTERNATOR.

LAUNCH OF THE MOTOR VESSEL "PORT HOBART."—On March 10, Messrs. Swan Hunter and Wigham Richardson, Limited, launched from their Wallsend shipyard the Port Hobart, a twin-screw motor vessel of 10,800 tons d.w., intended for service between Australia and the United Kingdom as a meat carrier. This ship is being built to the requirements of Lloyds Special Survey and Class 100 A.1, for the Commonwealth and Dominion Line, and has a length of 465 ft., a moulded breadth of 59 ft. 6 in. and a moulded depth to the upper deck of 43 ft. 9 in. The stern is of the cruiser type, while a topgallant forecastle is fitted. Of the five cargo holds, two heat-insulated ones are situated forward and one aft. A forward and an aft hold are both uninsulated. There are two masts and six hoists, which carry eight 10-ton and six 7-ton derricks. One 50-ton crane is fitted. The propelling machinery consists of two sets of four-cylinder two-stroke solid injection Doxford Diesel engines, of the opposed piston type. Oil fuel is carried in a tank in the double bottom of the Port Hobart, in a compartment below one of the holds, in a space below the engine room, in the deck tank forward and inside tanks in the engine room. All deck auxiliaries are electrically driven. On March 12 a somewhat similar vessel, the Port Dunedin, was launched from the North Yard, at Belfast, of Messrs. Workman Clark and Co., Limited, for the same owners.

TURBINE-DRIVEN PUMPING PLANT FOR THE RAND WATER BOARD.

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(For Description, see Page 412.)

Fig. 1.

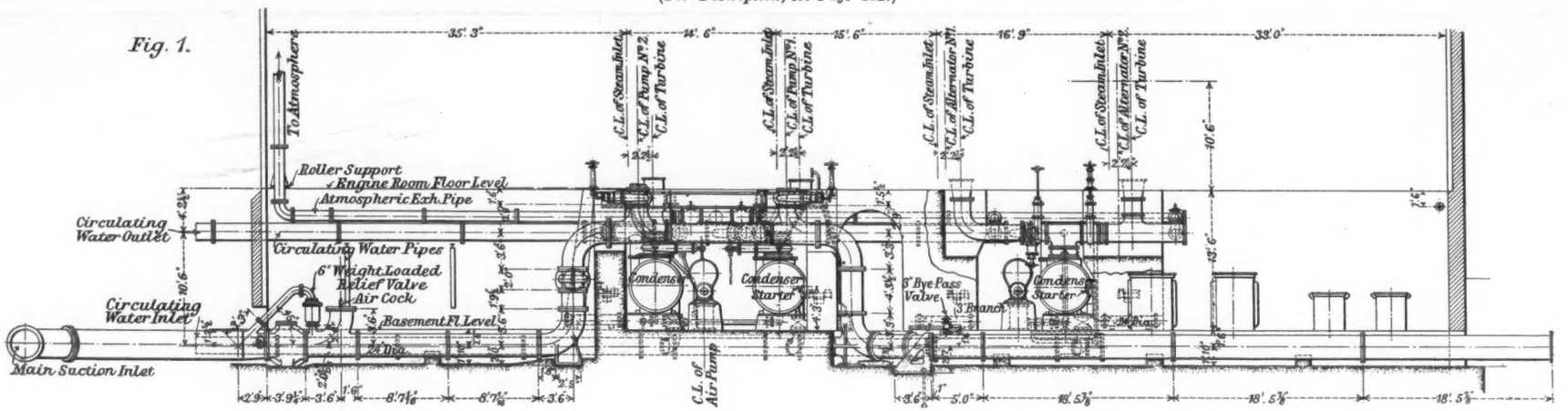


Fig. 2.

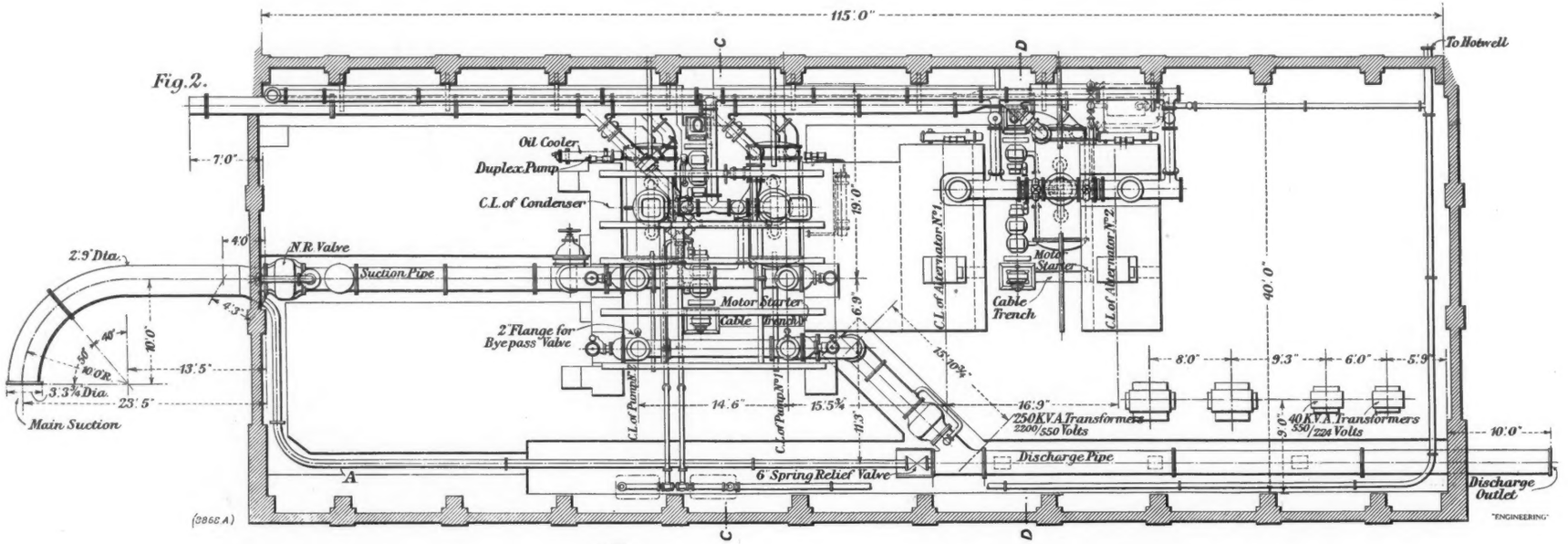


Fig. 3. SECTION C.C.

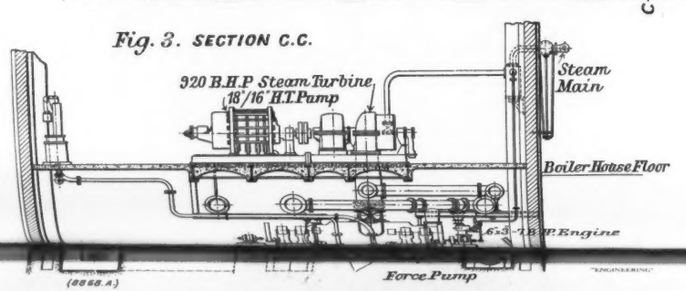


Fig. 4. SECTION. D.D.

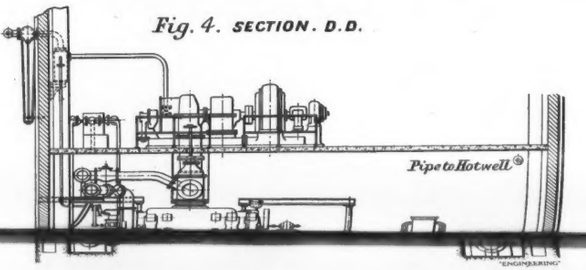


Fig. 6. SECTION B.B. VIEWED

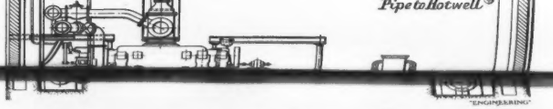
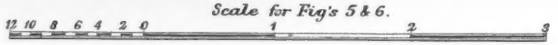


Fig. 5.

Scale for Figs 5 & 6.



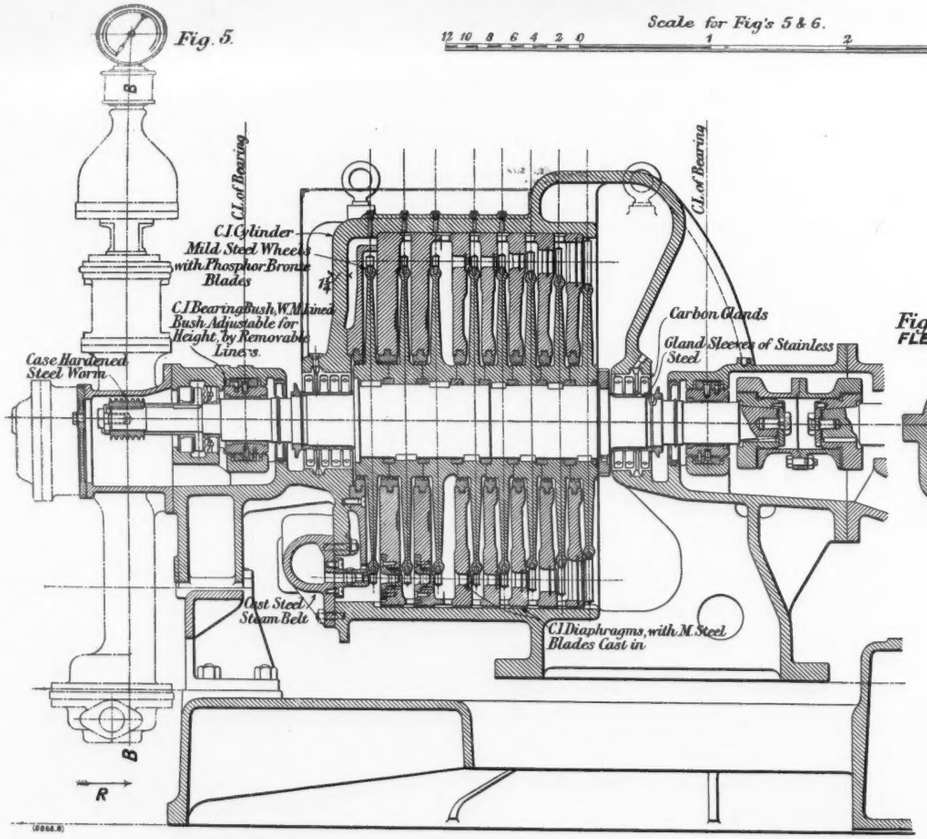

C.I. of Bearing
C.I. of Bearing
C.I. Cylinder
Mild Steel Wheels with Phosphor Bronze Blades
C.I. Bearing Bush W.M. lined Bush Adjustable for Height by Removable Liners.
Carbon Glands
Gland Sleeves of Stainless Steel
Case Hardened Steel Worm
Cast Steel Steam Belt
C.I. Diaphragms with M. Steel Blades Cast in
B
R

Fig. 7. END VIEW OF FLEXIBLE COUPLING.

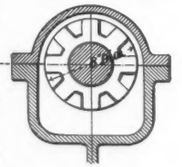


Fig. 6. SECTION B.B. VIEWED AS ARROW R.

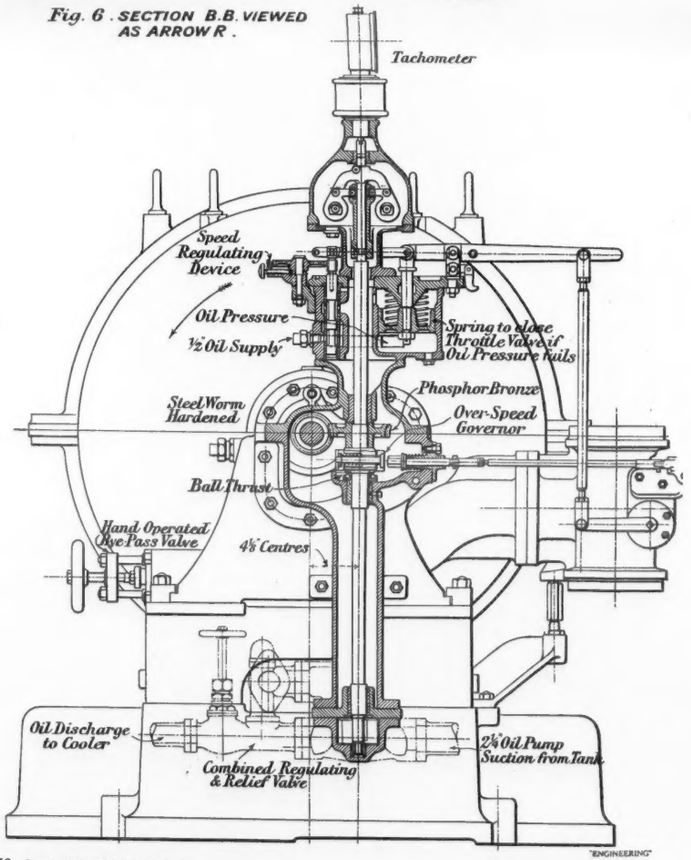


Fig. 8. SECTION THROUGH CENTRE LINE OF PINION

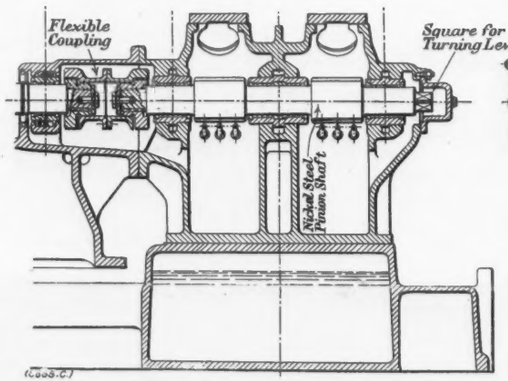


Fig. 9. SECTION THROUGH CENTRE LINE OF GEAR WHEEL

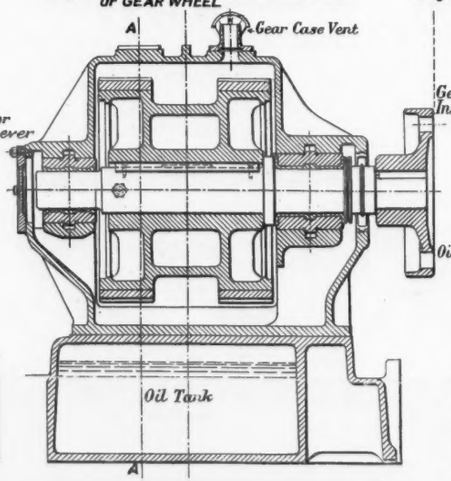


Fig. 10 SECTION ON LINE A.A. LOOKING TOWARDS COUPLING

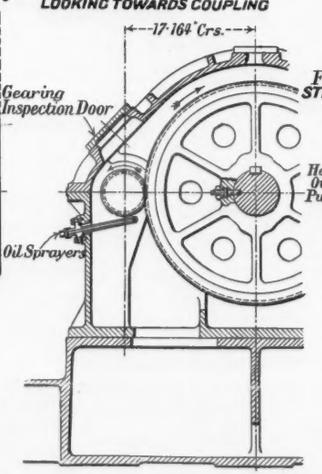
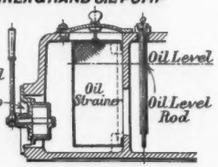


Fig. 11. SECTION THROUGH STRAINER & HAND OIL PUMP



ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

All accounts are payable to "ENGINEERING," LTD. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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TASMANIA: Gordon & Gotch Prop'ty, Ltd., Launceston: Hobart.

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Two-Page Plate.—TURBINE-DRIVEN PUMPING PLANT FOR THE RAND WATER BOARD.

The Proprietors of ENGINEERING trust that no great inconvenience was caused by delay in publication of part of last week's issue. In spite of the strike, the efforts made by their printers, Messrs. Harrison and Sons, rendered it possible for the whole issue to be despatched within a few hours of the normal time.

ENGINEERING.

FRIDAY, APRIL 3, 1925.

BOILER TRIALS.

IT was in 1902 that a Committee appointed by the Institution of Civil Engineers prepared a series of detailed instructions for the conduct of boiler trials, and published a set of standard forms for the tabulation of results. These were revised in 1914, but the subsequent very rapid advance in boiler-house practice has rendered them obsolete. Automatic stokers have come into general use; coal has, in some cases, been replaced by oil-fuel, and where this is not available, there is a growing tendency to adopt powdered coal, which possesses many of the advantages of liquid or gaseous fuels. It was obvious accordingly that a drastic revision of the existing code was required, and this has been entrusted to the Heat Engine Trials Committee, who have drawn up a provisional report which was discussed last week at the Institution of Civil Engineers.

In his lucid introductory remarks, Mr. W. H. Patchell explained that the forms submitted included many items which it might be neither necessary nor desirable to determine in ordinary commercial tests, but that it was considered advisable to use one and the same form both for these and for the more elaborate tests made with scientific ends in view. What is not required can be merely struck out; but the very fact that provision is made for certain entries will probably lead to more of them being included, even in commercial tests, than if separate forms were provided for the latter. One item that goes by the board is the time-honoured reduction of the evaporation "to from and at 212 deg. F." As matters stand to-day, this entry has nothing but precedent in its favour. The Committee also strongly recommend that the gross or higher calorific value of the fuel should be taken as the basis on which efficiencies are computed, and not the net. The latter is in fact somewhat indefinite. The gross value is what is given by the calorimeter, and represents what in ideal conditions would be wholly transmitted to the water and steam. It seems, therefore, both logical and desirable that it should constitute the standard of reference, but it would appear from Mr. Patchell's remarks, that Continental engineers are disinclined to follow suit, so that boiler efficiency figures recorded here and across Channel may not be directly comparable.

In this connection certain fallacies seem to have been fairly widespread, even in the recent past. Some of those who have discussed certain boiler trials have appeared to be under the impression that if the flue temperature fell below 212 deg. F., the whole of the vapour present would be deposited as water. Actually, of course, steam will not condense at 212 deg. F. unless its own pressure is 14·7 lb. per square inch or more. Even with oil-fuel, burnt under theoretically perfect conditions, less than 6 per cent. of the total molecules in the waste gases will be steam molecules, and the pressure of the steam will, therefore, even in this very special case be only about 0·88 lb. per square inch. Hence, at a temperature of 212 deg. F., it will be superheated by nearly 120 deg. F., and no condensation will occur on any surface of which the temperature is higher than some 95 deg. F.

In his contribution to the discussion, Mr. R. H. Parsons made the interesting suggestion that in progressive trials the heat units in the steam should be plotted against the heat units in the fuel. In such a plot an efficiency of 100 per cent. would be represented by a line making an angle of 45 deg., with the axes of reference. Some results thus plotted indicated a steadily increasing efficiency as the output was reduced (see page 379 *ante*). Clearly, at very low outputs, however, the efficiency must fall off, since even with the stop valve closed, some fuel must be expended merely to maintain the pressure. The rating at which the efficiency will be a maximum is represented by the point at which a straight line from the origin touches the plotted curve. In one series of tests discussed by Mr. Parsons, it was obvious that the maximum of efficiency was only reached at a very low output. On the other hand, another series he dealt with showed an increasing efficiency right up to the maximum output recorded. Such a result is certainly surprising, and suggests, at least, a reservation of judgment as to the reliability of this particular series of tests.

In any case it is evident that the rating of a boiler is a matter of no little difficulty. It will probably have to be settled by maker and purchaser in conference. Obviously a boiler with a large overload capacity cannot fairly be compared with another having little or none.

The provisional form prepared by the committee provides for a differentiation between the heat utilised in the boiler and in the superheater. It is perhaps questionable if this can be made with any very great degree of precision. Superheated steam at a stated temperature and pressure has a perfectly definite total heat. The same cannot, however, be said with respect to non-superheated steam containing moisture in suspension, the amount of which cannot be determined with accuracy. In the old days of no superheat and moderate pressures attempts were made to ascertain the quality of the steam by means of Peabody's ingenious throttling calorimeter. Owing, however, to the inaccuracy of the only steam tables then available, quite impossible results were not infrequently recorded. Now that very high pressures are coming into use we are confronted with similar troubles, since there is great difficulty in the experimental determination of the total heat of high-pressure steam at the saturation point. It is to be hoped, for scientific rather than engineering considerations, that the experiments now in progress here and in America will lead to concordant results. From the practical standpoint the total heat at saturation is now of steadily decreasing importance

since superheat is universal in large power stations and is being increasingly adopted elsewhere.

The opinion seems to be general that the only reliable method of measuring the quantity of water evaporated is by means of calibrated tanks. This distrust of steam and water meters is no doubt largely due to the fact that very fallacious figures may be recorded if a meter is unintelligently installed. Mr. J. L. Hodgson referred to several cases in which meters had been fixed close to bends or valves, whilst in other instances the attempt has been made to operate Venturi meters at condenser pressures or on wildly pulsating flows. Naturally, the results have been very unsatisfactory. The convenience of meters is, however, so great that we anticipate that their use will be widely extended in the not distant future. This tendency will be promoted by the policy already followed by certain makers, of organising an outdoor staff to advise on all meter matters, and to check meters *in situ*. Mr. Hodgson claimed that steam meters properly installed and maintained were reliable over a range of flow of 4 to 1, whilst water meters were accurate over a range of 9 to 1. Both ranges could, he said, be extended if users would face the additional cost.

One difficulty encountered in practice, is that it is often not convenient to carry out acceptance tests of boilers until the latter have been in regular service for some considerable time. What allowance should then be made for scaled and dirty surfaces can, however, hardly be laid down in a test code, but must be settled between the contractor and the purchaser.

In some cases it appears high efficiencies are required by the specifications, and penalties and bonuses offered for each $\frac{1}{2}$ per cent. of excess or deficiency. Where solid fuel is used it is pretty certain that variations of $\frac{1}{2}$ per cent. in efficiencies are illusory. Gaseous and oil fuels can, no doubt, be obtained of uniform quality, but coal cannot be sampled with equal precision, and its calorific value as fired is necessarily a little uncertain.

The committee do not specify what steam tables are to be used in computing efficiences. Some of the older tables are well known to be inexact, but this again is a matter which can, no doubt, be easily settled between maker and his customer. In this country it is probable that Callendar's table will be adopted by most. These are now the recognised standard of the British Electrical and Allied Manufacturers' Association, and have recently been extended and revised.

THE IMPERIAL MARKET.

THE fundamental contrast between the economic and industrial positions of a group of States that are united economically and of an Empire without a settled and coherent industrial policy can be seen in the records of American trade. The report, for instance, by Mr. J. Joyce Broderick, the Commercial Counsellor of H.M. Embassy at Washington, to the Department of Overseas Trade, and published by that Department during last year, drew attention not only to the events that had occurred in the United States during the year to which it relates, but also to many aspects of the American situation that are not realised generally. The United States is more than ever a mighty factor and a formidable competitor in all the markets of the world. But, as a fact, great as is its export business and keen as its manufacturers are in pushing it, the amount of its export sales is trivial relatively to its total production. The prosperity of the country depends little on the conditions that prevail in foreign nations. Its industrial welfare is based on the enormous market provided by the varied wants of its 110,000,000 people, distributed, as Mr. Broderick says, among 48 sovereign States unseparated by any regional or other barriers within, but strongly protected by tariff barriers against outside competition. With this basis its manfacturers are able to dispose of their surplus in export markets, shading their scale of production according to the demands of foreign customers, but maintaining uninterrupted prosperity by internal trade.

Of iron and steel, for instance, the United States exported some 2,000,000 tons in 1923, and about the same in 1922, as against about 3,000,000 tons in 1913; but the total production of pig-iron and of steel ingots for 1923 was over 40,000,000 tons of each, compared with which the quantities exported are trifling, and their fluctuations almost insensible. The number, again, of motor cars and lorries exported, including those of Canadian works in American ownership, was some 328,000, but twelve times as many were produced. The manufacture of the year's output took seven-tenths of the country's rubber supply, over half its upholstery leather, over a third of its plate glass production, and a fourth of its aluminium, and over 5,000 million gallons of gasoline were burnt in American automobiles. But perhaps the most striking indication of how the industry has grown up on its internal demand is the fact that some 14½ million automobiles are registered in the United States as against 2½ million throughout the whole of the rest of the world, or an average of something more than one for every other family throughout the country.

Vast markets like these do not result simply from high wages in other industries. The wages of any trade are paid by the consumers, who themselves are mostly wage earners, and, as a rule, can buy only as far as the price will allow the money to go. The home markets become great through three principal circumstances. Every man in them produces a relatively large amount. By reason partly of this large production, and partly of facilities for exchanging what men or factories own or produce for whatever commodities are desired, individual purchasing power is high. The relations between the States attract the bulk of that purchasing power to the home market. The material, whether of men or of natural resources, out of which the United States has built up this prosperity so quickly is much less than what is to be found in the British Empire, but it is used much more directly for its own purposes. The position of the United States in the export markets of the world shows that this concentration on home markets does not prevent the country from getting its full share of export business; on the contrary, the home trade is the stable base from which the export trade is fed, and to a considerable extent the export trade acts as a regulator to keep the home trade stable. This situation has been attained because the essential measures for concentrating on the home trade have been taken. The situation of the British Empire differs from that of the United States in having its States separated—or connected—by great tracts of ocean instead of by less distances of land, and doubtless the arrangements required to create a home Imperial market would not be identical with those that have been so successful in America. Nevertheless, if the creation of such a market were adopted throughout the Empire as a settled policy, to give effect to which appropriate measures were concerted and taken, the extent and variety of Imperial resources are such that a similar success could be expected.

The neglect to have constructed such a market out of the material in our hands explains most truly the hardship that we are undergoing in discharging our war obligations. The most direct remedy will be that all countries and parties within the Empire shall agree on permanent and effective measures, whereby such a market shall be created and maintained for the mutual benefit of the States within which it is constituted. We have already pointed out (p. 17 *ante*) that some such measures offer the best prospect of enabling the industries of the Empire to hold their own and grow in the face of the inevitable increase of German and other Continental exports. They would quicken the development of the resources of Dominions and colonies overseas, provide the mother country with increased employment and enlarged markets, and assure all the States of the Empire a greater and constantly growing production. The overall burden of administration would be increasingly diminished, and the standard of living would steadily rise. Every British industry, including particularly the engineering trades, must hope that those who direct the economic policy of the Empire will take practical account of these facts in the course they pursue at the present critical epoch of industrial history.

ZEPPELIN AIRSHIP DEVELOPMENTS.

IN a particularly interesting paper read before the Royal Aeronautical Society on the 26th ultimo, Dr. Hugo Eckener, of the Zeppelin Company, traced the development of the rigid airship from that designed by Count Zeppelin in 1900 to the Z.R. III constructed by the firm for the United States Navy, and delivered last autumn after the completion of a successful trans-Atlantic flight. The author mentioned, in the course of his remarks, that Count Zeppelin's first airship had an engine developing 15 h.p. and weighing 480 kg., while that of his second ship, completed in 1905, developed 80 h.p. for the same weight. Further improvements in engines were such that, during the last stages of the war, airship engines of almost exactly the same weight developed 260 h.p. He referred to the increase of speed resulting from improvements in the form of the vessels and to the increased efficiency of structural design which had enabled the ratio of useful lift to gross lift to be increased from 25 per cent. in the vessels produced just before the war to 56 per cent., which was the figure for the Z.R. III.

As further evidence of the progress made, he stated that the last-mentioned airship, with a gas capacity of 70,000 cub. metres, could travel at a speed of 18 metres per second with an engine of 400 h.p., whereas the last airship produced before the war, having a gas capacity of only 18,000 cub. metres, required 500 h.p. to give the same speed. With the engine power mentioned, he added, the ratio of useful load to gross lift would be 65 per cent. in the case of the Z.R. III, and 25 per cent. for the pre-war vessel. The author attributed many of the improvements in airship design made by the Zeppelin Company to the use of the wind channel, which formed part of the equipment of the works at Friedrichshafen. This wind channel, he added, had a useful diameter of 2·9 metres, and wind velocities up to 50 metres per second could be obtained. After giving some particulars of the design of the Z.R. III and of its trans-Atlantic voyage, the author discussed the real and imaginary dangers of airship travel, finally giving a carefully-considered estimate of the expenditure on, and revenue from, a possible trans-Atlantic airship service. In this he took the case of a vessel having a useful lift of 15 tons and making 50 trips each way per annum. The lift he divided between 30 passengers, accounting for 5 tons, 5 tons of mails and 5 tons of goods. The revenue from the passengers at 125*l.* per head would be 3,750*l.* and that from the mails and goods would be 8,350*l.* and 3,750*l.* respectively, the earnings for each voyage thus amounting to 15,800*l.* The working expenses were put at 10,000*l.* per trip, leaving a substantial margin of profit, sufficient, in fact, to pay 34 per cent. per annum on the capital of 1,750,000*l.* required for a service on the lines indicated.

Finally, the author emphasised the necessity for international collaboration in the development of airship transport, with which some of the speakers in the discussion on the paper, notably Sir Alan Anderson, expressed their complete agreement.

THE LATE MR. H. E. JONES.

DEATH has claimed many distinguished victims during the last month, and has not spared veteran engineers. Last week we had to announce the death of Mr. Robert White, at 83 years of age, a link with pioneer railway work. To-day we regret to have to record the death of Mr. Harry Edward Jones, only a few months his junior, and closely connected through his father with the early days of the gas industry, which antedated the railway era. Though the alchymist J. Joachim Becher, prepared his "philosophical light" by coal distillation in 1680, and Lord Dundonald illuminated the hall of Culross Abbey by coke-oven gas in 1786, and W. Murdoch lighted his house in Cornwall by coal gas

in 1792 and had done the same for factories in Soho by 1803, the real development of the gas industry coincided with the early railway age. Mr. H. E. Jones had a share in the vigorous activity of the gas industry of half a century ago. Subsequently he witnessed the stagnation into which gas engineering fell owing to the absence of competition, the shock and impetus that the advent of the electric lamp gave to the gas burner, and the remarkable recovery of the gas industry from that experience. Always a very active man, noteworthy as a designer, manager and consulting engineer, he died on the afternoon of March 24 at his residence, Marsden Ash House, Ongar, Essex, having been on horseback in the morning,

Harry Edward Jones was born in April, 1843, as second son of Mr. Robert Jones, M.Inst.C.E., a well-known gas engineer, who became in 1853 gas engineer to the Commercial Gas Company of East London, after having held similar appointments in Wolverhampton, &c., and remained there till 1880. Young Jones was educated at the City of London School and Stepney Grammar School, leaving the latter after having passed the Cambridge Higher Local Examination with honours. Having been apprenticed to Joseph Beattie, locomotive engineer of the South Western Railway, he joined the Harlow gas works, worked as student in Medlock's Laboratory, and became in 1860 gas engineer, and soon afterwards engineer-in-chief to the Wandsworth and Putney Gas Company, the works of which were reconstructed under his own supervision. After various professional journeys to Lisbon and Oporto, Athens and Spain, he joined the Ratcliff Company in 1869. This company amalgamating in 1875 with the Commercial Company, he was made joint engineer with his father, whom he succeeded in 1880. The new works of the company at Poplar were designed and constructed by him. When H. E. Jones retired from this position in 1902 he was succeeded by his son, Mr. Stanley Jones, the present engineer and general manager of the company. Mr. Jones did not, however, sever his 41 years' connection with the company, but accepted a seat on the board as deputy-chairman.

His later activities have mainly been in consulting work. He was much in demand in this country and also abroad, as consultant, arbitrator and expert witness, and was a familiar figure in Parliamentary Committee rooms and with the Board of Trade. He was consulting engineer to a large number of companies and, though limiting his duties, he was till the end chairman of the Wandsworth, Wimbledon and Epsom Gas Company, and other companies in this country, the European Company which owns eight works in the north of France, and companies in Bombay and Buenos Aires.

As regards his connection with the large engineering bodies, he became a full member of the Institution of Civil Engineers in 1875 and was its president in 1917. The three noteworthy papers he contributed to that body brought him the Telford medal and premium in 1875, the Watt medal and Telford premium in 1880, and the George Stephenson medal and Telford premium in 1901. His paper of 1875 on "The Construction of Gas Works" occupied the Institution fully for three evenings. The discussion of the 1880 paper on "Gas Purification" was opened by Vernon Harcourt, who pointed out that ammonia might appear at the outlet of purifiers though not detectable at the inlet, and was continued by Dr. William Siemens. His paper of 1901 on "Modern Practice in the Manufacture and Distribution of Gas," which dealt also with the three far-reaching innovations of that time, Welsbach burners, commercial meters and the sliding-scale and which concerned means of cheap gas supply, was criticised by Mr. Brackenbury because it did not refer to mechanical operation. His presidential address of November, 1917, dealt with gas for metallurgists, by-product recovery and general features; he might, as Sir Alexander Kennedy said in proposing a vote of thanks, have given a great many more figures without covering so wide a ground. The occasion was exceptional, it may be remembered, since Mr. Jones had stepped into the office in place of Mr. W. B. Worthington, the president-designate, who had been taken ill. Mr. Jones took part in only one of the discussions of other papers. It was during the discussion of Mr. Thomas Clarkson's paper on "Commercial Motor Vehicles" in March, 1914, when he commended the White steam car and mentioned that he transported coal by 10-ton steam-trucks at a total cost of 2*d.* a ton-mile.

He made another reference to automobiles at the Institution of Mechanical Engineers, when road locomotives were discussed in June, 1909; he then wanted to restrict the speed of motor cars to 9 miles because they frightened horses by their speed and smell. Mr. Jones was a keen sportsman, a follower of the Essex hounds for sixty years and fond of driving a four-in-hand; but he took up motoring soon after the date just mentioned. The contribution he made to the proceedings of the Institution of Mechanical Engineers was the fourth Thomas Hawksley lecture of 1916 on "Gas Engineers of the Last Century," giving particulars of the lives of the men in days when Parliament spoke of companies for "furnishing luminous vapours."

Though Mr. Jones presented only one paper on "The Illuminating Power of the Gas of the Future" to the Institution of Gas Engineers in 1902—he was President in 1903-4—he did a great deal in reorganising the Institution in 1912, and his donations provide in perpetuity means for awarding the London Gold Medal for the best paper of the year on subjects of practical interest to the gas engineers. In his presidential address he referred to the need of training gas engineers, the advocacy of which has led to the drawing up, by the Institution in conjunction with the Board of Education, of a scheme under which the institution issues certificates which the Board endorses. Mr. Jones was also first president of the National Gas Council, established during the war, for promoting the interests of the gas industry in Parliament, Government departments and in other directions.

A frequent correspondent to the technical press, and hard working, he expected much of those with him, but he was ungrudging in praise and was respected for his broad, fair views and knowledge. He was a strong advocate of profit-sharing. He was a Justice of the Peace and his private library testified to his wide interests. Of a sound constitution, he retained the freshness of youth and also some of his militant spirit till the end. He was buried at Ongar cemetery on March 30, and a memorial service was held in Savoy Chapel at the

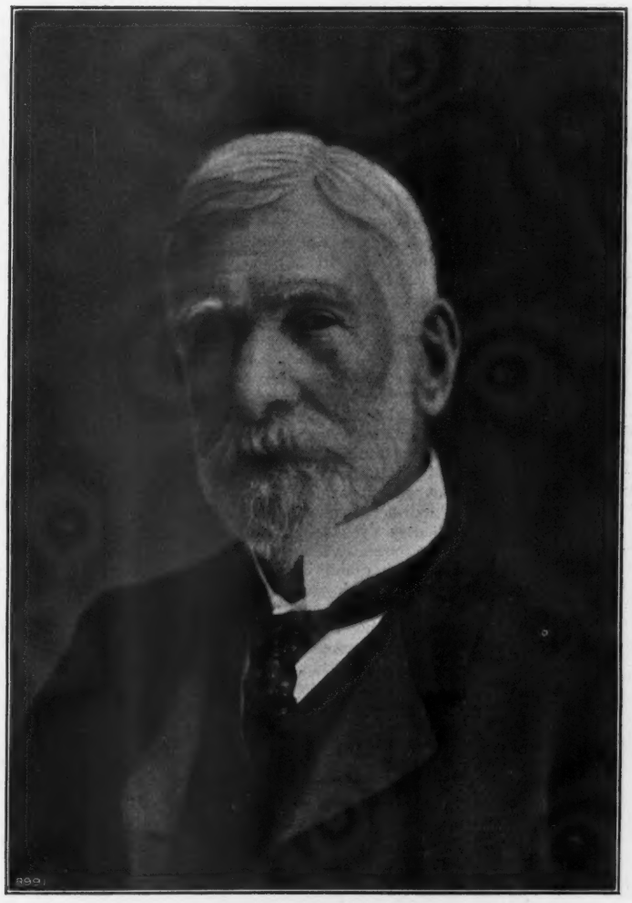


Photo by Elliott and Fry.

THE LATE MR. HARRY EDWARD JONES.

same time. He leaves three daughters and two sons, Mr. Frank and Mr. Stanley Jones, both representing the third generation of gas engineers in the family,

THE INSTITUTION OF NAVAL ARCHITECTS.

THE annual general meeting of the Institution of Naval Architects was held this year in the Lecture Hall of the Royal Society of Arts, John-street, Adelphi, W.C.2, the session commencing on Wednesday morning last. The President of the Institution, His Grace the Duke of Northumberland, occupied the chair. The programme included the reading and discussion of 14 papers which were arranged to be dealt with at sessions held on the morning of Wednesday, the morning, afternoon and evening of Thursday, and the morning and afternoon of to-day. The evening of Wednesday was devoted to the annual dinner, a reference to which is made below. As usual, we give in this issue an account of the proceedings of Wednesday, leaving the subsequent sessions to be be dealt with later.

REPORT OF COUNCIL.

The first item on the agenda was the report of the Council for 1924, which was read by the Secretary. Notwithstanding the continued depression in the shipbuilding industry, the membership of the Institution had increased by 143, but deaths and resignations during the year amounted to 157, so that the total membership had been reduced by 14. The figures for 1922, 1923 and 1924 were 2,888 2,914 and 2,900 respectively. M. Emile Bertin, a member of the Institution since 1873, had died during the year, and the Council wished to record their appreciation of his valuable services to naval architecture. Mention was also made of the names of Mr. H. E. Deadman, Sir Edward Beauchamp, Admiral Sir W. A. D. Acland, Sir Thomas Fisher and Mr. Robert Duncan, whose deaths had been recorded with regret. Reference was made to the summer meeting, held in London in June last, jointly with the Scottish and North-East Coast Institutions, and duly reported in our columns at the time. A statement of receipts and payments for the year, appended to the report, showed a satisfactory surplus of revenue over expenditure, and gave financial data relating to the various scholarships administered by the Institution.

The Institution's scholarship in naval architecture had been awarded to Mr. L. Digby, and the Beardmore and Fairfield scholarships to Mr. W. M. Mc Kitterick and Mr. R. G. S. Kennedy, respectively. The Weir scholarship in marine engineering was gained by Mr. G. G. McDonald, and two post-graduate research scholarships by Mr. J. Lockwood Taylor and Mr. S. A. Hodges. The Gold Medal and Premium of the Institution had been awarded to Engineer-Commander R. Beeman and Professor K. Suyehiro, the former for a paper entitled "Further Experimental Work on Diesel Engines" and the latter for a paper dealing with the drift of ships caused by rolling among waves.

Referring to the work of the William Froude Tank, the report stated that a sum of 5,000*l.* per annum was needed, and mentioned that the Department of Scientific and Industrial Research, in certain circumstances, would be prepared to contribute one-half of this amount provided the balance was raised by the industries concerned. The Committee on Large-scale Skin-Friction Experiments, set up last year under the chairmanship of Sir Richard Glazebrook, had prepared a report which would be included in the Transactions. The Committee's conclusion was to the effect that much more could be done by tank experiments, although considerable extension of the data would be required for the purpose of framing ship estimates. A majority of the Committee was of the opinion that the towing of a destroyer hull would give the additional data required and that the expenditure involved in such an experiment would be justified, although in view of the existing trade depression it was not thought expedient to take any further steps involving considerable expenditure at the present time. The annual report referred to amendments framed by the Council for the purpose of raising the standard of qualification required of candidates for membership, mentioning that the proposals would be submitted at the meeting, and, if passed, would take effect in 1926. A list of representatives of the Institution on various other bodies was given, and the fact that the secretary of the Institution, Mr. R. W. Dana, had been made an honorary member of the Royal Society of Engineers in Holland, was also mentioned.

ELECTION OF OFFICERS.

The report having been put to the meeting and duly carried, the Secretary announced that, as a result of a ballot, the following had been elected as officers and members of council of the Institution:—Vice-President, Mr. W. J. Berry; Members of Council—Messrs. G. S. Baker, T. Carlton, W. H. Dugdale, John Gravell, Andrew Hamilton, Robert Traill, and Professor J. J. Welch, Engineer Rear-Admiral W. M. Whayman, and Engineer-Commander W. M. Wisnom. As associate members of council, the Marquis of Graham, Sir Robert A. Hadfield, and Mr. J. Herbert Scrutton were elected. The Gold Medal and Premium of the Institution, referred to in the report, were then handed by the President to Engineer-Commander S. R. Dyke on behalf of Engineer-Commander Beeman, and to Captain T. Toyoda on behalf of Professor Suyehiro.

PRESIDENTIAL ADDRESS.

After the presentations had been made and acknowledged, His Grace, the Duke of Northumberland delivered his address, referring first to the satisfactory character of the report on the work of the Institution. He then remarked that the meeting was being held in a critical period in the history of shipbuilding, which, with shipping, was one of the key industries of the British Empire and one on which its future depended. The existing difficulties, he thought, would be overcome in the future, as similar difficulties had been in the past, but it would be folly to overlook or under-estimate the extent of these troubles. We had now not only to contend with the keenest competition from abroad, but with unparalleled labour difficulties at home. Shipowners were now unable to place orders in this country at satisfactory prices, and consternation had recently been caused by the ordering in Germany of five motor-ships for British owners. The current Navy estimates provided little comfort for shipbuilders as they contained no vote for new construction, although it was possible that some cruisers would be ordered later. The prime factor in the cost of production, His Grace continued, was wages, and in this connection he mentioned that skilled shipyard workers in Germany were paid 33*s.* 6*d.* for a 54-hour week as compared with 56*s.* 8*d.* for a 47-hour week paid in this country. Among the proposals made to deal with the situation, it had been suggested by Sir Alfred Mond and others, that industry should be subsidised by a sum equivalent to that now paid in unemployment doles, and this, he thought, might tide over a temporary crisis. Another remedy would be the reduction of rates and taxes. One cheering feature of the situation was that it was fully realised by those concerned, and efforts were being made to bring both parties together. The difficulties, he thought, could be overcome by co-operation. One of the chief difficulties in regard to wages was the discrepancy between those paid in the sheltered and unsheltered industries, a feature which influenced the entry of young men into the latter. In conclusion, His Grace referred to the importance of research to the future of the shipbuilding industry, adding that, although the William-Froude Tank had done much excellent work, its future activities were threatened by lack of support. He pointed out that if ¼*d.* per ton of output were contributed by the shipyards, a sum of 1,500*l.* per annum, would be obtained, this sum being the amount required for the work of the Tank to be continued. Finally, he appealed for immediate contributions for the work and for the production of a scheme to ensure a permanent income.

COMMERCIAL EFFICIENCIES OF DIESEL- AND TURBINE-DRIVEN VESSELS.

The President then called upon Sir John Harvard Biles to present his paper on "Relative Commercial Efficiency of Internal-combustion and Steam Engines for High-Speed Passenger Vessels." We commence to reprint this paper on page 414 of this issue of ENGINEERING.

Mr. H. Ruck-Keene, Chief Engineer-Surveyor of Lloyd's Register of Shipping, opened the discussion by agreeing with the author of the paper that the use of steam machinery was still warranted. He then called attention to the figures given for the various systems of propulsion which showed that the annual cost of running with the use of high-pressure steam turbines was less than that for Diesel engines. The personnel of the engine-room staff was a matter that warranted consideration, but the adaptability of the sea-going engineers had been shown, and the difficulties previously experienced when oil engines were introduced had been overcome, as doubtless would prove to be the case with any other deviation from the previously-used types of plant. It had been found in the actual operation of Diesel-driven ships that the adjustments which had to be made to the propelling plant were far fewer than was the case with steam machinery.

Engineer-Captain W. Onyon continued the discussion by stating that he did not think that Sir John Biles had made out as good a case for steam machinery, as it is to-day, as he might have done. Reliability, although the first consideration in dealing with the selection of ship-propulsion machinery, was not referred to at all in the paper. The only questions considered were those of economy, but if through lack of reliability a vessel lost one voyage in ten it might mean a loss to the owners of something between 20,000*l.* and 30,000*l.* It would take a great improvement in economy of running to make up for such a loss due to lack of reliability. The paper referred to high-speed vessels, but mention was made of the Aorangi, which, as it has a speed of 17 knots, should not be classed as a high-speed ship. The reversion from rotary to reciprocating plant was, he thought, a retrograde step. He had witnessed many ships' trials, and seen many breakdowns at sea. Of these he remembered five in which the propelling plant was put out of action by the breaking of connecting rods. The figure given for the Aorangi's consumption of fuel per shaft horse-power hour, 0·431, he assumed was that obtained in the 60-hours' trial on the Clyde. No mention was made of the oil fuel for the boilers supplying steam for auxiliaries, nor was any statement made whether refrigerating plant was in operation.

If the results obtained with the Aorangi, the Orama, and the Conte Verde were compared they might learn something of the relative consumptions of fuel in the different systems of working. In the Orama the daily fuel consumption was 136 tons for all purposes, and in the Conte Verde 155 tons. Had electric auxiliaries been used in the Conte Verde there would have been a reduction of oil used of 1 ton per hour. Again had pre-heating been adopted another 4 per cent. or 5 per cent. reduction would have been obtained, and the fuel used per day would have been 124 tons. Diesel oil cost 3*l.* 14*s.* per ton and boiler fuel oil 2*l.* 14*s.*, and making allowance for the difference between the vessels considered, a steam-driven vessel corresponding to the Aorangi would save some 13*l.* per day. This could be obtained without making use of high pressures or high temperatures. The lubricating oil figure given seemed to be excessive. The turbine was a very flexible power unit, whereas the Diesel engine was not, and it might be concluded that that was the reason for the large reserve of power on the Aorangi. One great advantage of using steam plant was that the oil fuel could be replaced by coal should oil prices become prohibitive.

The Hon. Sir Charles A. Parsons called attention to the fact that on land they did not find large Diesel engines in use for generating electricity. The reason was that oil engines were very costly, unless they were of small power. Only in small units were they more economical than steam plant. The turbine results approached closely to those of the Diesel engine in large sizes and in very large units showed to greater advantage. It was difficult to understand why there was so much conservatism in the views of marine engineers regarding steam

plant. In the past ship's practice had followed that on land, where pressures of 500 lb. per square inch were already in use. It was wise not to go to excessive values of pressure, for the present, on ships, although plant was under construction in America for use on land in which pressures of 1,200 lb. per square inch were to be used. The boiler-makers were satisfied that they could manufacture boilers which could be maintained with ease, in fact as easily as those for low pressures. They had to prevent any tendency for salt to get into the boilers and this could be done by dividing the work of condensing into sectional units. Were that done it would be possible to cut out a section in which a leak of the salt water, used as circulating water, had developed, and run at less power until a repair had been effected. There were no difficulties in making turbines for very high pressures, and he would welcome the views of boiler-makers on the question from their standpoint. He, Sir Charles, was prepared to guarantee to propel a ship with steam turbines with results equally as good as those obtained with Diesel engines.

Mr. Harold E. Yarrow stated that as a boiler-maker, he saw no difficulties whatever in making boilers for high pressures, if they were properly designed, especially in regard to mountings. With effective co-operation of the steel makers it was possible to construct boilers at much higher pressures than those at present contemplated. Mr. Yarrow then gave some figures obtained in tests with water-tube boilers fired with oil or with coal on chain-grate stokers and making use of preheated air, which showed efficiencies of 85 per cent. He had no hesitation in saying that such boilers could be supplied for marine purposes with that efficiency.

Mr. W. J. Belsey referred to the excellent results obtained in land power stations even when comparatively low pressures of steam were used, and spoke of the advantages to be obtained if electric transmission were put into service for ships.

Mr. R. J. Walker thought that Sir John Biles had been conservative in dealing with the economies of steam turbines. In the paper he had given the oil fuel consumption for such plants as 1 lb. per s.h.p.-hr. but he (the speaker) had had experience of a geared turbine ship, in which 0·8 lb. had been used for all purposes. He was also satisfied that a figure 5 per cent. lower than 0·7 lb. per hour, given by Sir John Biles for all purposes, could be obtained with the high-pressure turbine plant. In preparing Table II, for 27,000 shaft horse-power it was estimated that the steam used was 7 lb. Allowing what might be considered a fair consumption for auxiliaries, 1·65 lb., they obtained a total steam consumption of 8·65, corresponding to an oil consumption of 0·66 per shaft horse-power-hour. This was for a case where the steam pressure was 500 lb. per square inch, the total temperature was 700 deg. F., the vacuum 29 in., and the boiler efficiency 84 per cent., the auxiliary exhaust being used to heat the feed to 200 deg. F.

The factors in consumption were the efficiency of the turbines, the steam used for auxiliaries and the efficiency of the boilers. For the auxiliaries there were three alternative possibilities, the use of independent steam auxiliaries, electrical driving by means of a turbo-generator of high efficiency, or the use of a Diesel engine for the electric generator drive. The ideal condition was obtained when all the exhaust from the steam auxiliaries could be used for feed heating. Pure water was not always used for circulating purposes on land; for example the water used for the North Tees station was brackish. The value of preheating the air used in the furnaces was now established. High pressure turbines could be applied to such cargo vessels as the Cairnross with an advantage in economy of about 15 per cent.

Professor J. J. Welch then referred to a paper by Professors A. L. Mellanby and William Kerr (see ENGINEERING, of March 6, 13 and 20 last, page 301, *et seq.*), read at the North-East Coast Institution of Engineers and Shipbuilders, in which the limits of temperature and pressure which could be used in land plants had been discussed. While they could not go to the extreme limits proposed for land purposes it was interesting to note that the decisions the authors arrived at were that 900 lb. per square inch pressure and 1,000 deg. F. were regarded as reasonable limits for the present.

Sir James Kemnal said that water-tube boilers were at present on order for 14 vessels. It was strange to hear of the nervousness regarding salt entering the boilers. There was no greater danger at 500 lb. pressure than at 250 lb.

He had no hesitation in stating he was prepared to guarantee steam plant at 500 lb. pressure for marine purposes. They were engaged at present on a land installation, in which steam would be generated at 800 lb. per square, and the exhaust from the turbines would be obtained at 200 lb. to feed the existing plant.

Sir Westcott Abell said there was little doubt that up to a certain size of vessel the advantage lay with the Diesel engine. Shipowners had become convinced that Diesel ships were wanted, and they must not lose sight of the fact that these were the people who were concerned. There was no struggle for supremacy between the Diesel engine and the steam turbine, it was rather a case in which the improvements effected in the oil engine-propelled vessels accelerated efforts to introduce modifications of the older steam practice. It was a fact that considerations of thermal efficiency were frequently allowed to affect the problem to a greater extent than was warranted by the actual economy of running obtained.

Professor P. Hillhouse spoke of the logs of the Aorangi showing fuel consumption results of 0·46 lbs. per shaft horse-power hour, for all purposes and 0·32 lb. for the main engines alone, which were close to the figures given in the paper. He also called attention to the fact that the saving in deck area in motor vessels was on the lower deck, due to the absence of boilers and not on the upper decks. He suggested that when the author was dealing with the saving of deck area the extra length for a steam vessel should be 40 ft. rather than the 4 ft. given in the paper. He thought the value given only allowed for the change in the deck hatches. The principal advantage of Diesel engines was only obtained in vessels which undertook long voyages.

Mr. J. H. Narbeth called attention to the important place taken by British engineers in the development of the oil engine.

Sir John Biles, in reply to the discussion, said it was a most striking thing that those who favoured the use of the Diesel engine were not present. He certainly should not have referred to the Aorangi as a high-speed vessel, as he thought they should always specify the actual speeds and discard ambiguous terms. Reliability was obviously the first consideration demanding attention. In this respect there was little history available regarding the Diesel ships. He intended to review the figures relating to lubricating oil. Regarding the question of salt water entering water-tube boilers he had taken the opportunity of asking those using such boilers what was their experience and in every case found that no troubles had been experienced. He was glad to have the reassurance of Sir James Kemnal that joint troubles had long since been got over. The turbine was certainly as good as the Diesel engine and he thought that he had not done the turbine an injury in what he had said. For turbines of 55,000 h.p. the weight would be 3,600 tons, while for those of 27,000 h.p. it was 2,700 tons. The weight did not increase in the same ratio as the power as was practically the case with Diesel engines.

The Duke of Northumberland, in calling for a vote of thanks to Sir John Biles, referred to the great value of the paper, which was indicated by the conclusions arrived at in it not being disputed. The meeting then adjourned until the afternoon.

JAPAN'S CONTRIBUTION TO NAVAL ARCHITECTURE.

The two papers left over from the morning meeting were taken in the afternoon, when His Grace, the Duke of Northumberland again occupied the chair. The first paper dealt with was one by Dr. F. P. Purvis, entitled "Japan's Contribution to Naval Architecture," an abstract of which will be found on page 429 of this issue. After Dr. Purvis had read his paper, the chairman stated that written contributions to the discussion on it had been received from Sir Philip Watts and Mr. W. J. Berry, and would be read by the Secretary.

Sir Philip's contribution referred to the fact that the Esmeralda, a cruiser built by Messrs. Armstrong many years ago for Chile, had attracted a great deal of attention, and Japanese officials visiting this country at the time had ordered two vessels of the same type, viz., the Naniwa and the Takachiho, from the firm. They were of 3,700 tons displacement, and the principal armament was two 10-in. and six 6-in. B.L. guns. Particulars were then given of a number of warships constructed by Messrs. Armstrong for the Japanese Navy while Sir Philip was with the firm from 1885 to 1902 most of the vessels having been designed by him and built at Elswick. The Japanese were believers in the desirability of having, firstly, a gun armament as powerful as possible in relation to the size and type of the vessel, and, secondly, as high a speed as possible consistent with other qualities. Dr. Purvis had not considered it necessary to give much detail of the ships referred to in his paper, but particulars could be obtained from Sir Philip's own papers read before the Institution in 1905, 1911 and 1919. He wished to confirm the author's statements with regard to the work of Japanese students at the Royal Naval College, Greenwich, and added that he knew that this work had borne good fruit when the students returned to their own country. Mr. Berry's contribution also related to the excellent work of Japanese students in this country, and he attributed this not only to their industry and ability, but also to their early training in Japan under Dr. Purvis.

Captain T. Toyoda, who then spoke, congratulated the author on his paper, and remarked that it was extraordinary to him how the naval constructor was able to meet, and, even to anticipate, the requirements of the fighting branch of the Navy. Dr. Purvis had referred to Japan's indebtedness to outside help in the development of naval architecture. That was quite true and would always be remembered in Japan. Progress had been remarkable and he hoped that, before long, Japan would be able to take her place in maintaining the progress of naval architecture throughout the world.

Sir Archibald Denny, the next speaker, said his firm had been privileged to assist the Mitsubishi Company in the establishment of the experimental tank referred to in the paper. They had been asked to look after and collect the necessary material, had trained a member of the Mitsubishi Company's staff in the working of the tank, and also sent out one of their own men to Japan for that purpose. Captain Toyoda, he continued, had referred in generous terms to Japan's indebtedness to this country, but it must not be forgotten that we also owed a debt to Japan.

The discussion was continued by Professor P. Hillhouse, who remarked that having occupied the Chair of Naval Architecture at the Tokyo Imperial University for four years, it had been a particular pleasure to him to hear Dr. Purvis' paper. He referred to the earnestness displayed by Japanese students and to the language difficulties involved in educational work, adding that the dockyards and shipyards in Japan dealt sympathetically with students by allowing them access to the yards during holiday periods so that they could obtain practical information.

The next speaker, Commander Taji, referred to the value of Dr. Purvis' educational work in Japan, and added that Dr. Purvis had also read many valuable papers before the Japanese Society of Naval Architects and had also contributed to the discussions. The speaker acknowledged Japan's indebtedness to outside help in the development of naval architecture and remarked, with regard to Dr. Motora's device for damping the rolling of ships, referred to in the paper, that it was still in the experimental state. It was not quite correct to say, as Dr. Purvis had done, that Japanese boys could not get to the university without first passing through a middle school and then a high school; a considerable number, in fact, had actually done so. Finally, he remarked that the name of Dr. Purvis should be added to the list given in the paper of

the names of British naval constructors who had been of assistance to Japan.

The last contribution to the discussion was made by Sir John H. Biles, who, in the course of his remarks, said he had visited Japan on several occasions, the last time being shortly after the earthquake. He considered it very remarkable that he had then been able to carry out the duty entrusted to him by the Government of India of investigating the condition of the Japanese mercantile marine. He wished to take the opportunity of saying how much we were indebted to Japan for supplying information on the subject under the particularly difficult circumstances existing at the time.

He referred to the veneration with which Japanese students regarded Dr. Purvis and finally remarked that although the Japanese workers held the view that they must be kept employed whether there was any work available or not, the shipbuilding industry of that country appeared to be in a flourishing condition and was certainly able to produce good ships.

Dr. Purvis, who was then called upon to reply, said he had little to say except to thank the speakers for their references to him personally and for the manner in which his paper had been received. The chairman, after thanking Dr. Purvis, called on Mr. G. H. Hoffmann to read the next paper on the programme.

The Longitudinal Strength of Ships.

This paper was devoted to an "Analysis of Sir John Biles' Experiments on H.M.S. Wolf in the light of Pietzker's Theory." As a member of the Committee on Destroyers in the year 1905, Sir John Biles presented to the Institution of Naval Architects, a paper on the tests conducted on the destroyer Wolf. The general result of these tests was that the ship was found to be not nearly so stiff as might have been anticipated from theoretical considerations. As a measure of the ship's failure to fulfil the theoretically-deduced characteristics, the modulus of elasticity of the ship as a whole was recorded. The relationship of this reduced modulus of elasticity to the modulus of the plating was exactly the same as that of the external bending moment of the straining forces to the internal moment, which would correspond to the recorded strains, all longitudinal members being taken as fully effective. The conclusion that in a ship, the value of the modulus is lower than in an experimental strip of plating, was based on the underlying assumption that the whole sectional area of the ship's longitudinal members might be taken as fully effective. Pietzker took as his basic principle that it was highly improbable that a strip of solid plate should show a modulus of 14,000 tons to the square inch when in the testing machine, and only one of about 10,000 tons when built into the ship. Therefore, he concluded that the reduction in the factor of stiffness did not originate from a lower value of the modulus, but from the fact that we could not take the whole of the ship's section as being fully effective, and the moment of inertia should be reduced. In calculating the effective moment of inertia, Pietzker took the plating along longitudinal members to be fully effective for a width of 40 to 50 times the thickness; that is, 20 to 25 thicknesses on each side of the stiffening member. The remainder was considered ineffective. Mr. Hoffmann examined the results obtained in the Wolf experiments from this standpoint.

Mr. J. Foster King, of the British Corporation Registry, in opening the discussion argued that it was not possible to conceive that the modulus of elasticity of the material could alter in its changed location. Ships under service conditions were not subject to greater working stresses than 7 tons per square inch. He had had to find a standard for use in dealing with thin plating in compression. Using Wöhler's formula with 7 tons as the working stress, it was found that it was fully effective to have the span 80 times the thickness, which agreed with what was the case in the Wolf.

Sir John Biles said he did not regard the paper as adverse criticism of their work on the Wolf, but rather as adding to the value of their deductions. From the Wolf experiments they were able to see that the stresses at sea never exceeded those in dock. Mr. Hoffmann had extended their work by studying parts of the structure which were yielding longitudinally by bending between the frames, and came to the conclusion that the stress was sometimes greater than that obtained from a belief in the uniform distribution of stress.

After Professor Abell had referred to the difficulties of making observations on large structures, he discussed the actions of bending stresses on the plating in the bottom of a vessel.

Dr. A. M. Robb then said that the original explanation of the discrepancy between the "deflection" modulus and the "tension" modulus was that some of the rivets slipped. This was unwise as it upset their views on a ship as a homogeneous structure and was confuted by the results of Dr. Montgomerie's experiments. There was nothing but empiricism in the Pietzker value of 50 for the relationship of span to width of plate. Allowance must be made for buckling and shear. It was the case that the deck of the Wolf was extensively pierced and it was possible that the whole area of the deck was used in the calculations.

Mr. C. E. Stromeyer referred to his strain indicators, which were used on the Wolf and the experiences he had had in their use since. He then called attention to the strains in boilers, in certain experiments, being much in excess of what could be accounted for and said that some part of the effect might be due to the tilting effect of the lap joints. He wondered if very wide plates behaved according to "Hooke's Law" or was it the case that the cross stresses affected the elongation.

Mr. L. Woolard, quoted the author as stating that the Wolf was found not to be nearly so stiff and strong as might have been anticipated from theoretical considerations. Sir John Biles' experiments, however, showed that the Wolf's structure was capable of withstanding high stresses and though her strength was slightly under the theoretical value, based on solid material, the strength was not brought into question. They had to remember that St. Venant's theory of bending was only approximate even when applied to a solid beam.

Mr. Hoffmann, in reply, said that if they could see a way to avoid the contradiction of using the two values of the modulus they must take it. He thanked the contributors to the discussion and promised to deal fully with their comments in the Transactions.

The Duke of Northumberland then expressed the appreciation of the members for the work that the author had placed before them and proposed a vote of thanks to him. The meeting was then adjourned until Thursday morning.

The Annual Dinner.

The annual dinner of the Institution was held on Wednesday evening in the Connaught Rooms, about 600 members and guests being present. His Grace the Duke of Northumberland presided, and, in proposing the toast of "The Naval and Air Forces," referred to the difficulty of establishing a settled foreign policy in the present disturbed situation of world affairs. In the course of his reply for the Navy, the Rt. Hon. W. C. Bridgeman, M.P., First Lord of the Admiralty, said he had it on the authority of the Prime Minister that there would be full opportunity for the introduction of a construction programme supplementary to the current estimates. He mentioned also that, since the war, the five great naval Powers between them had laid down 35 cruisers, 193 destroyers and 105 submarines, the numbers contributed to these totals by Great Britain being five, four and two, respectively. These figures, he remarked, served to prove that our naval policy was not an aggressive one. Air Chief-Marshal Sir Hugh Trenchard, responded briefly on behalf of the Royal Air Force. The response to the toast of "The Mercantile Marine," proposed by Baron Hayashi, the Japanese Ambassador, was made by Mr. John Denholm, President of the Chamber of Shipping, in a particularly interesting speech, and the toast of the Institution was proposed by the Rt. Hon. Sir Joseph Cook, High Commissioner for Australia. To this Sir Charles Ellis responded.

(To be continued.)

THE RATING OF MACHINERY.

In our issue of February 20, 1925, we commented on the report of the Inter-Departmental Committee on the Rating of Machinery and Plant in England and Scotland. Under present case law, machine tools and process machinery of all descriptions are liable to be taken into account as contributing to the assessable value of factory properties in England, but in Scotland machine tools and appliances are specially exempted from rating. In this connection, however, it must be remembered that in England all rates are paid upon a net value, whereas in Scotland all rates except parish rates are paid upon a gross value, and that in England the contractor's basis is less rigidly applied than in Scotland. Broadly speaking, the essential features of the report of the Inter-Departmental Committee are that the differences between the methods of rating as between the two countries should continue, and that as regards England and Wales, machinery and plant should be divided into two classes; Class I. to include what may be regarded as permanent factory equipment, such as power, lighting, and heating plant, shafting, &c., and Class II. to include the actual machine tools and plant which may be regarded as more or less peculiar to the particular business which is carried on in the factory. The Committee recommended that machinery and plant in Class I. shall be rated as if it were actually part of the hereditament, and that in Class II. should only be rated at 25 per cent. of the full value.

When dealing with the report, we suggested that it might occasion some disappointment to English machinery users; and that this is actually the case is shown by a strong protest which has now been issued by the Machinery Users' Association, who represent upwards of ten thousand manufacturers and traders throughout the country. The Association have promoted a Bill, which is down for Second Reading to-day, and which proposes in effect that machinery coming under Class II. shall be exempt entirely from rating after the date of application of the Act, which is given as April 1, 1927.

The Bill has been promoted on the grounds that the inclusion of machinery and plant in estimating the value for purposes of local rates of hereditaments occupied for trade, business, or manufacture, places an undue burden on users of machinery and plant; and that the alleviation of this burden will assist British Manufacturers to meet foreign competition in the markets for British goods, both in the United Kingdom and abroad, on more even terms. There can be little doubt that the adoption of the recommendations of the Inter-Departmental Committee would have the effect of a still further increase in the overhead charges of a large number of firms, and as these already constitute a very serious handicap to the development of trade, the efforts of the Association are certain to meet with wide-spread sympathy and support. It appears reasonable to suppose, however, that if the Bill which they are promoting should become law, some dissatisfaction will be felt in Scotland, as from what we have said above, it will be clear that manufactures in the latter country will be placed in a somewhat unfavourable position as compared with those in England and Wales.

The Institution of Mining and Metallurgy.—The annual dinner of the Institution of Mining and Metallurgy was held at the Hotel Victoria on March 25. In proposing the toast of the Institution, Sir Atul Chatterjee, K.C.I.E., High Commissioner for India, stated that the mineral production of India was developing very rapidly and had nearly quadrupled in value between the years 1908 and 1920. A College of Mining had been founded in India, which he hoped would be a feeder institution to the Imperial College of Science, London. Mr. Humphrey M. Morgans, in his reply, drew attention to the importance, both from a scientific and from an imperial point of view, of the Empire Council of Mining and Metallurgical Industries, founded at Wembley in 1924. Mr. Basil Mott, President Inst. C.E., in acknowledging the toast of kindred societies proposed by Mr. H. L. Sulman, stated that the training in metallurgy he had received fifty years ago at the Royal School of Mines had proved of very great value to him during his engineering career. He further stated that closer co-operation between the leading technical societies was being brought about and would be productive of much good. Other speakers included Professor S. J. Truscott and Sir Francis G. Ogilvie.

LABOUR NOTES.

THE hope is general in industrial circles that the result of last Friday's conference in London on the state of the British shipbuilding and ship-repairing industries will be the setting up of the joint committee of investigation which Mr. John Barr, the president of the Shipbuilding Employers' Federation, suggested in the course of his very able and extremely interesting speech. Mr. Barr indicated clearly the difficulties with which British shipbuilders and ship-repairers have to contend in their competition for work with Dutch, German and French firms, and there was agreement, even on the side of the men's representatives, that he did not exaggerate the trouble. High rates, dear material and fuel, and heavy transport charges were handicaps, he suggested, that were beyond the control of the shipbuilding industry itself, though something might, in his opinion, be done to lighten them by the exercise of joint pressure by the employers' federation and the trade unions. Much could be done, however, to relieve the situation—and to relieve it at once—by making a joint effort to approximate shipyard working conditions here to those obtaining in the Continental countries which were our strongest rivals.

"There can be no doubt," Mr. Barr said, "that Continental shipbuilders have a very great advantage over us because the segregation of men into unskilled and skilled groups is very considerably less defined with them that it is with us, and a still greater advantage, probably, because the further segregation of skilled men into all sorts of unions is much less developed with them than it is here. There may be considerations by reason of which organisation within trades rather than in one craft union may from the workers' point of view in shipbuilding be desirable. We would be the last to deride pride of union and of craftsmanship within separate unions, but surely there should be proper arrangements for the elimination of intercraft disputes on matters that really do not go to the vitals of the individual trade. Instances can be quoted in great number where cost is enormously added to in shipbuilding by a want of proper elasticity as between trade and trade, and where also cost is enormously added to by lack of elasticity as between the skilled and semi-skilled person. Excessive sub-division is without question one of our most serious handicaps as compared with the Continent, and if hours and wages are to be maintained on their present level, then there must be some extensive relaxation in this direction. These are problems that we recognise we can only expect you to look at in the concrete and not in the abstract, and, while we have no desire whatever to impinge upon what you regard as the proper functions of trade unionism, we are really quite seriously of opinion that unless a broader spirit of tolerance is shown there is a risk of both your interests and ours being impaired beyond all recovery. The highest function of a trade union, after all, is to promote the best interests of its members, and these best interests are not always promoted by an exhibition of a too carefully guarded jealousy."

Other directions in which he thought great relief could be obtained in the matter of costs were indicated by Mr. Barr. "Payment by results can be extended," he said, "with a resultant improvement to the status of your own members and a quickened and less costly production in the industry. The full use of machinery and facilities is being made almost prohibitive by want of proper accommodation between the unions and ourselves. There surely can be no doubt in anyone's mind that the more labour-aiding machinery we can have the better we are equipping the industry, and at the same time the better are we making the status of the worker. But for the proper organisation of the industry we must have greater facilities in the use of machinery, and in the use of labour. Nothing can be gained—indeed, there is everything to lose—by our closing our eyes to the proper evolution in industry, and holding on to practices which, though of respected age, may be a complete hindrance to the proper development both of the crafts and of the industry. In so far as the introduction of up-to-date machinery is impeded, or in so far as its installation adds to costs instead of lessening them, we are as an industry inflicting a further handicap upon ourselves in competing with countries which are developing their shipbuilding resources free of restrictions and past customs. I am passing these things under review, not for the purpose of asking that definite progress be made to-day upon them, but rather in order to appeal to you as responsible persons in the industry to have an open mind in approaching the questions so that a solution may be found along lines which are perfectly fair to the worker, and, at the same time, are a help to the industry.

Mr. Barr's proposal to set up a joint committee to investigate costs outside the industry, as well as costs within it, was sympathetically received by the majority of the men's representatives, but instead of agreeing to it at once they decided to refer the matter to the executives of their trade unions, and meet the employers later in conference. At the time of writing, efforts are being made to arrange such a meeting for some day next week.

In reply to a question in the Commons, the Parliamentary Secretary to the Ministry of Labour (Mr. Betterton) stated that the weekly working hours in shipbuilding yards were 47 in this country and 54 in Germany. The weekly time rates were given in a tabular statement which was circulated in the official report of Parliament. According to this, shipwrights in nine principal shipbuilding centres of Great Britain received 55*s.* 7*d.* per week, and ship joiners 57*s.* 9*d.* per week; the same classes employed at Hamburg and Stettin received 31 Reichmarks, or 30*s.* 10*d.* sterling per week. No information was available as to the weekly wages of British semi-skilled workers, but at Hamburg and Stettin men of that class received 29·16 Reichmarks, or 29*s.* sterling per week. In this country unskilled workers were paid at the rate of 38*s.* 5*d.* per week, while in the two German centres named they were paid at the rate of 25·38 Reichmarks, or 25*s.* 3*d.* sterling per week. In notes, it was added, that the German rates were those paid to single men. Supplementary allowances were paid to married men at the rate of 1 pfennig per hour for a wife, and 2 pfennigs per hour for each child. For a married man with two children that represented an addition of 2*s.* 8*d.* per week. The weekly rates for Germany were obtained by multiplying the hourly rates given in the source by 54, and converting the results into English currency at the rate of 20·10 Reichmarks to the pound. For both countries the rates given were based on minimum agreed time rates (per week in Great Britain per hour in Germany). In both countries rates in excess of the minimum were, in practice, frequently paid. Furthermore, no allowance was made in respect of extra pay for piecework or for overtime. Consequently a comparison of the average weekly sums actually earned in the two countries might yield different results.

The Ministry of Labour States that on March 23, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,201,300—926,600 men, 32,500 boys, 213,300 women, and 28,900 girls. On March 16, 1925, the number was 1,219,206—938,934 men, 34,141 boys, 215,999 women, and 30,132 girls, and on March 24, 1924, it was 1,063,519—786,610 men, 32,310 boys, 212,058 women, and 32,541 girls.

A meeting of the International Sub-Committee of the Trades Union Congress General Council was held in London on Tuesday for the purpose of discussing the final arrangements for the conference which is to take place next week with the representatives of the Russian trades union movement. The purpose of the conference is officially said to be to discuss ways and means of removing the difficulties now existing in the way of the Russian trade union organisation becoming affiliated to the Amsterdam International Federation of Trade Unions. The representatives of the All-Russian Trade Union Council will be M. Tomsky, G. N. Melnichansky, Olga F. Chernichowa, I. I. Lepsy, N. P. Glebov-Avilov, V. M. Mikhailov, V. Y. Yarotsky (interpreter), and E. T. Makarova (technical secretary). The British representatives will be: Messrs. A. B. Swales, A. A. Purcell, H. Bothman, J. W. Bowen, G. Hicks, E. L. Poulton, Robert Smillie, M.P., W. Thorne, M.P., B. Tillett, R. B. Walker, Fred Bramley (secretary), and Miss J. Varley. The first meeting has been fixed for Monday at the headquarters in London of the British Trade Union movement.

The National Minority Movement is naturally opposed to the idea of an industrial peace. In its official organ the executive Council "warns the workers of the present discussions on industrial peace and class conciliation. This is only taking place," adherents are told, "because of the great industrial struggles ahead, which will be lost, with disaster to the whole movement, unless the workers themselves repudiate this pernicious and false doctrine. "At this moment," the pronouncement proceeds, "particularly when the metal, railway and miners' unions are agitating for wage increases, it is more necessary than ever that these powerful sectional unions should combine for common action. We, therefore, call upon the executive committees of the unions involved, together with the General Council of the Trades Union Congress to form a Committee of Action for the realisation of all the various demands. In the event of strike action, no union to return to work until the demands of all the sections have been met. "If this is done," the manifesto concludes, "it will give a powerful stimulus to the whole working class movement, and will line up all our forces for a real fighting attack upon the exploiters."

In a reference to the look-out in the English north-western area of the employees of co-operative societies, the Manchester correspondent of *The Times* expresses the opinion that the wages and hours of labour demanded by the workers are wages and hours of labour which the overwhelming majority of members of co-operative societies would regard as millennial conditions if they could get them in their own case. Lancashire miners are receiving at the present time from 35*s.* to 50*s.* a week. Cotton operatives are not averaging 34*s.* a week and have not earned more for four years. A skilled engineer's pay is 55*s.* 6*d.* a week. The union is demanding 65*s.* a week for male assistants of 21 years of age, 70*s.* at 22, and 75*s.* at 23, and for women at these respective ages 50*s.*, 55*s.*, and 60*s.* For branch managers it claims from 90*s.* to 140*s.* for a 44-hour week. The union wants a 38-hour week in offices, full pay during sickness, and increased pay for overtime.

Mr. Stephen Walsh's Coal Mines (Minimum Wage) Bill came up for second reading in the House of Commons on Friday last. Mr. Walsh said that compared with pre-war wages the miners' standard had fallen far behind the cost of living, and that hundreds of thousands of people were living in a state of constant impoverishment and misery. Lieut.-Col. Headlam moved the rejection of the bill on the ground that while establishing a rigid minimum wage, it withdrew from those directly concerned the power to settle their own affairs by consultation and conference on conditions prevailing at any given time. Colonel Lane-Fox, Secretary to the Mines Department, in replying for the Government, said that the bill would entail a considerable addition to the burdens of the industry. The motion for the second reading was defeated by 208 votes to 143, and the amendment, when put substantively, was carried by 197 votes to 121.

A two days' stoppage of work in the London printing industry caused considerable inconvenience last week to firms engaged in the production of weekly and other periodicals. The origin of the trouble was a difference between a North London firm and five of its workers over the rate which should be paid for operating a new binding machine. The question of a rate for this particular machine had been under discussion for some time by the industry's joint conciliation body, but no decision had been arrived at. Claiming that other firms were paying the rate put forward by the union, the five workers withdrew their labour, and a lock-out was decided upon by the London Master Binders of the members of the Bookbinders and Papermakers' Union. The federation to which the workers' organisation was affiliated retaliated by giving notice of a strike, which eventually took place. After protracted negotiations, however, the matter was adjusted and most of the workers returned to duty. The main points of the agreement arrived at were, Mr. Goodwin, the Secretary of the Master Printers' Federation, stated, an undertaking that all parties would respect the constitution of the Joint Industrial Council and take no aggressive action until the rule of the Joint Industrial Council dealing with disputes had been fully complied with. It was also provided that in future all negotiations in the binding industry should be on national lines. The scale of rates for special machines, both for London and the provinces, was fixed, and finally the recommendation of the Conciliation Committee with regard to the works in which the dispute originated was accepted without any reservation. The strike, which caused the Master Binders to lock out members of the Bookbinders' and Paperworkers' Union, was begun, it may be added, without regard for the Joint Council's constitution.

Interesting statistics relating to the extent of Soviet Russia's industrial output during the first quarter of the current economic year are given in the *Soviet Union Review*. In an editorial note it is pointed out that, while the increase of production during 1923–24 was, on the average, 30 per cent. above that of 1922–23, the programme for the current year anticipates an increase of 37 per cent. to 40 per cent. above that of last year. The figures given show that the anticipated improvement is being realised. In a few industries—amongst them machine construction—output has fallen below the programme by from 11 per cent. to 18 per cent., while in several others, including the manganese, steel and electro-technical industries, the programme has been exceeded by 15 per cent. to 26 per cent. For the most part, however, the actual output has not varied more than 10 per cent. on one side or the other. Our contemporary regards that as a clear indication that the Supreme Economic Council has been able to arrive at a correct estimation of the factors determining the rate of development of Soviet industry, and also of the future possibilities of expansion.

CATALOGUES.

Filters and Coolers.—The Visco Engineering Co., Limited, 162, Grosvenor-road, London, S.W.1, have issued a leaflet relating to their sheet-metal products which include filters, water coolers, fume and steam removal apparatus, &c.

Ship Propellers.—Messrs. James Pollock, Sons and Company, Limited, 3, Lloyd's-avenue, London, E.C., have sent us a catalogue containing a full description, with illustrations, of the Star contra-propeller, and pointing out the advantages to be derived from its use.

Castor Seed.—A booklet of information about the cultivation of castor seed and the manufacture and uses of castor oils, has been issued by Messrs. Mirrlees Watson and Co., Limited, Scotland-street, Glasgow. Some information is added about sunflower and other vegetable oils.

Electrical Machines.—A copy of their monthly house journal has been received from the Société Alsacienne de Constructions Mécaniques, Belfort, France, containing illustrated articles on electric locomotives, road vehicles, and various lifting and carrying cranes. The text is in French.

Electrical Machinery.—A descriptive catalogue of drum controllers and resistances for 2-phase and 3-phase slip-ring induction motors up to 100 h.p. has come to hand from the British Thomson-Houston Co., Limited, Rugby. A priced list of direct-current motors up to 30 h.p. has also been received.

Oils.—A blue print showing graphically the lubricating efficiency of mineral or fatty oils and the effects of adding their germ preparation to these oils, has been received from the Henry Wells Oil Company, Limited, 11, Haymarket, London, S.W.1. The graphs are based on laboratory and practical working tests.

Pumps.—The vertical pumps for tube wells and bore-holes, patented by Messrs. Ashford and Leggett, Amritsar, India, are now being made by the Mirrlees Watson Company, Limited, Scotland-street, Glasgow, who have sent us a very interesting catalogue containing a full description of the pump and auxiliary apparatus.

Electrical Machinery.—Messrs. Brown-Boveri, Limited, Trafalgar House, Waterloo-place, London, S.W.1, have sent us a copy of their house journal, published in Switzerland, containing articles and notes on high-voltage rectifier installations, the speed regulation of induction motors, an automatic pumping station, &c.

Thrust Bearings.—From the Kingsbury Machine Works Company, Philadelphia, U.S.A., we have received a catalogue of thrust bearings made by them, with rocking blocks or shoes and oil retaining casings. These bearings, of which lists of standard sizes are given, are mainly suitable for dredgers and marine propellers.

Electric Power-Station Plant.—An illustrated description of the turbo-generator, rotary converter, and switch-gear constructed and installed at the electricity-supply works of the Blackpool Corporation is given in a four-page catalogue issued by the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2.

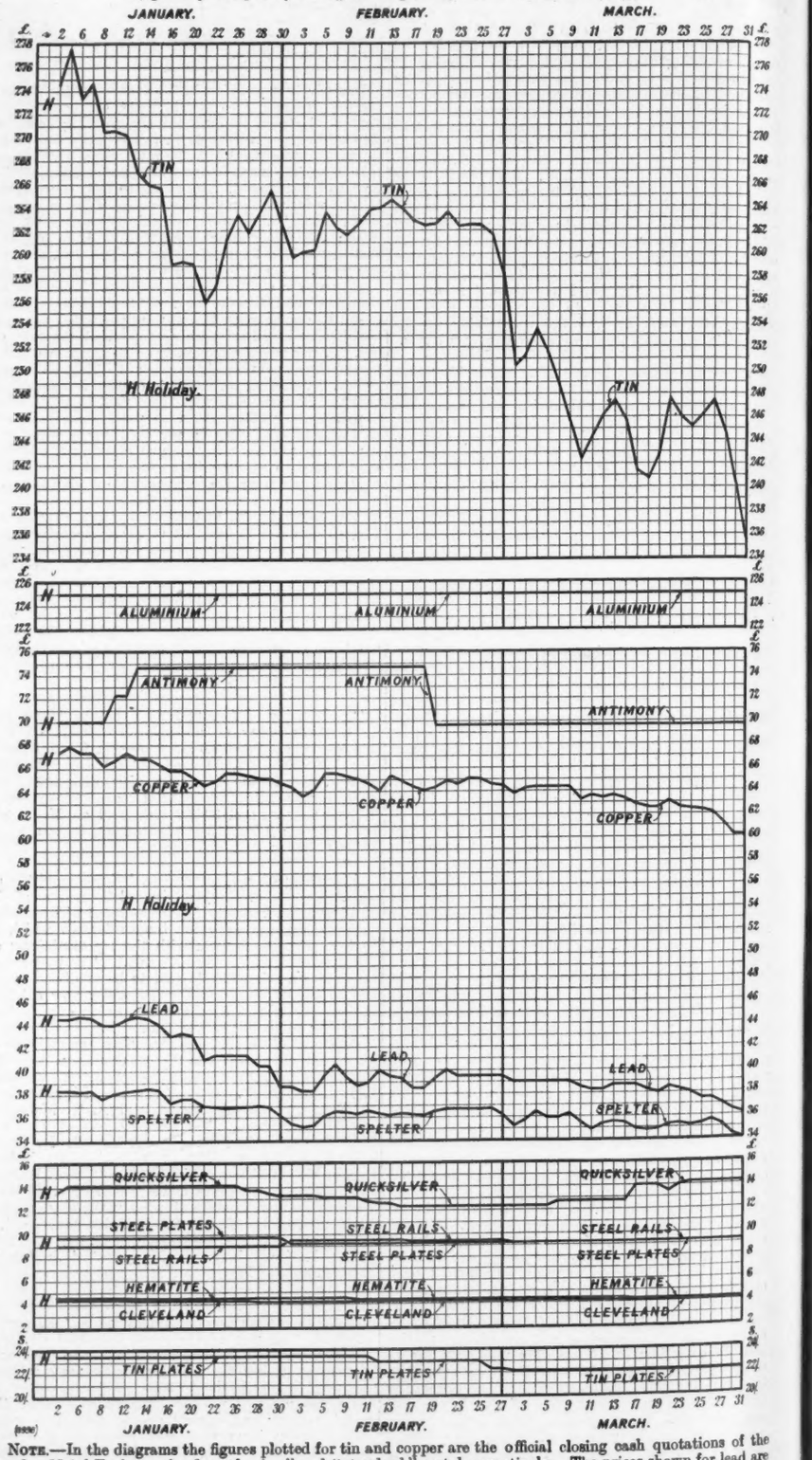
Wiring Supplies.—A new catalogue of wires, varnishes, insulators, insulating materials, jointing materials, tools, screws, &c., is to hand from the General Electric Co., Limited, Magnet House, Kingsway, London, W.C. The catalogue is well arranged for easy reference with tables of dimensions, weights, &c., and in nearly all cases prices are given.

Sheet Rubber.—A sample of rubber sheeting, which is very strong and tough and has a very finely finished surface, has come from Mr. Louis Minton, Trevelyan Buildings, Manchester, together with a circular indicating the purposes for which it is suitable. The finish is produced by a patented process which any rubber manufacturer may use under licence.

The Wireless Telegraphy and Signalling Bill.—The Council of the Institution of Electrical Engineers have addressed a letter to the Postmaster-General in which it is pointed out that, in the Council's opinion, some of the provisions of this Bill are of far-reaching importance, and, unless modified, will prove a hindrance not only to wireless telegraphy and radio science, but also to electrical and physical research and to the progress of electrical science generally. The Council urge that it should be made clear that the words "any apparatus for wireless telegraphy" do not apply to such apparatus except in connection with wireless telegraphy, inasmuch as many pieces of apparatus, such as condensers, crystal detectors, valves, &c., are now in common use in physical laboratories, and by electricians generally for quite other purposes than wireless telegraphy. The Council strongly recommend that all regulations made by the Postmaster-General under Clause 3 of the Bill should, before being placed before Parliament, have been previously submitted to a statutory Advisory Technical Committee for their consideration, such a Committee to be representative *inter alia* of the Royal Society, the Institution of Electrical Engineers and the Radio Society of Great Britain. Clause 7, which applies the provisions of the Bill to the use of etheric waves for the transmission of energy, might greatly interfere in directions quite outside its object, namely, to prevent interference with wireless telegraphy. It is suggested that for this clause a new one be substituted rendering liable to penalties anyone using electro-magnetic radiations of the radio frequencies commonly used in wireless telegraphy in such a way as injuriously to interfere with the working of authorised wireless telegraphic stations.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption The price of quicksilver is per bottle, the contents of which vary from 70 lbs. to 80 lbs. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

JAPAN'S CONTRIBUTION TO NAVAL ARCHITECTURE.*

By DR. F. P. PURVIS, Emeritus Professor of Naval Architecture, Tokyo Imperial University.

IN the Transactions of the Institution of Naval Architects there are eight papers written by Japanese members and contributors. In view of the difficulties in their way the contribution of these papers shows not a little enterprise on the part of their writers. More accessible to them is the Japanese Society of Naval Architects (the *Zosen Kyokai*), which has been exceedingly active since its foundation in 1897.

The contributions to the *Zosen Kyokai* have been for the most part in Japanese; but other papers contributed in English appeared as presented. While in Japan, the author did what was possible to secure the translation into English of every contribution of value for publication in this country (chiefly in ENGINEERING), but was often not successful; it was always difficult to get Japanese friends to take the responsibility of translation. A good many papers were contributed by Dr. Suyehiro, some in English and some in his own language. Naturally, his papers to our Institution have been anticipated by similar papers to his home society, among them his exceedingly interesting experimental contributions to us of 1920 and 1924. In the *Zosen Kyokai's* semi-Jubilee year 1922, Dr. A. M. Robb presented a paper on the strength of ships. In the course of this he referred with appreciation to two papers by Dr. Suyehiro on shearing stress in a ship's structure, read before the same society, one in 1912 the other in 1921. Of these two the 1912 paper was reproduced in full in ENGINEERING of December 27, 1912. Dr. Suyehiro's two papers demand most careful consideration from any future investigator who works at the subject of shearing stresses.

Japan's indebtedness to outside help is no doubt a prominent feature in the material and other progress she has made. This country's share in that help is notable in many directions. In 1877, the British Admiralty sanctioned the admission of one young constructive officer of the Imperial Japanese Navy as a student of naval architecture for two years at the Royal Naval College at Greenwich. In 1879, a student of marine engineering was similarly sanctioned. Since that time, with some gaps, there has been a succession of students in each subject for the full course of three years.

Other countries besides our own have had their share in rendering help. It would be interesting but outside the purpose of the present paper, to give an account of Japan's technical advisers from time to time. There is one who must be mentioned. M. Emile Bertin, who was engaged in Japan from 1885 to 1890, for the purpose of assisting in the reorganisation of her dockyards and fleet. Two ships were built to his design in France, and two at Yokosuka Imperial Dockyard. In company with the name of M. Bertin, it seems only natural to record the names of the British constructors—Sir Edward Reed, Dr. Elgar, Sir William White, Sir Philip Watts, and Sir Alfred Yarrow. At various times, and in various ways, they did not a little to assist Japan in the development of her Navy.

In 1909 the Japanese Navy Department commenced the construction of its experimental tank at Tsukiji, Tokyo; experiments were started in 1911 under the direction of Constructor Vice-Admiral (then Rear-Admiral) Kondo. Its dimensions were 500 ft. by 20 ft. by 11 ft. depth of water; an addition of 80 ft. to the length was contemplated but never carried out. The structure was wrecked by the terrible earthquake of September 1, 1923, and completely destroyed by the fire that followed. The loss of this tank will be temporary only, as the Navy Department has instituted studies to help towards the building and equipment of a new tank adapted to its needs.

Another experimental tank in Japan is that constructed in 1908 by the Mitsubishi Shipbuilding Company at their Nagasaki shipyard—its dimensions are 430 ft. by 20 ft. by 12 ft. depth of water; from the first Dr. Motora has been in charge. Of the work done at this tank not much information has been published; but in 1922, Dr. Motora described (in Japanese) to the *Zosen Kyokai* an invention of his own which he had thoroughly tried out in it. The invention consists of oscillating bilge fins projecting one from each bilge of a ship; they are actuated mechanically in such a way that the plane of the fins lies always in the proper relation to the direction compounded of the ship's motion ahead and the up and down motion of fin; this position would give a minimum of fore and aft fin resistance and maximum of vertical, thus damping the ship's rolling. The dimensions of fins contemplated for a ship 400 ft. long are 5½ ft. by 4½ ft. When not in use they are drawn up into recesses provided in the ship's sides. His apparatus has been applied to a small steamer, the Mutsumi Maru, used on a local service. It is said to have met with sufficient success to be applied to a larger steamer, the Keifuku Maru, 360 ft. long.

In 1904, during the Russo-Japanese War, the Japanese Volunteer Fleet Association became active as a body analogous to the Russian Volunteer Fleet, so influential and important in the days of its power. Three ships were built in Japan under the auspices of this association; they may have fulfilled the expectations formed of them, but did not establish any particular record. In 1914 the functions of the Japanese body were extended to embrace also ship classification duties and the hope was entertained that this side of its functions might develop into an important national responsibility. The Association then, or earlier became known as the *Teikoku Kaiji Kyokai*, words which have had a varying English translation and are now rendered Imperial Japanese Marine Corporation.

Japan's influence, direct and indirect, on the development of modern types of warships, would form an interesting study; but this must be left to those who have taken an active part in the naval progress of the last two decades. One detail may be referred to here, and that is the design and construction of the Tsukuba and Ikoma, laid down at Kure Imperial Dockyard in 1904 and launched in 1905 and 1906; armoured cruisers with a displacement of 13,750 tons and speed of 21 knots, they were the first to be provided in the development of the type with an armament of four 12-in. guns. These ships are regarded in Japan as initiating in some respects the evolution of the battle-cruiser type.

In the United States there have been a number of ships to which the Sperry Gyro Stabiliser has been applied, the largest being the troopship Henderson, of 10,000 tons displacement. Japan is the first country outside the U.S.A. to adopt this appliance; of dimensions also not previously attempted. The seaplane carrier Hosho, of 9,500 tons displacement, was completed at the Yokosuka Imperial Dockyard in 1922, and to make her more efficient she is fitted with the stabiliser.

On the engineering side developments have taken place corresponding with the progress made otherwise in maritime matters in Japan. In the Navy Department Engineer Rear-Admiral Fujii told us in 1911 of water-tube boilers of the "Miyabara" and the "Navy" type. The construction of the Miyabara boiler, he says, "is comparatively simple, having horizontal water and steam drums with slightly curved tubes connecting them." After severe tests Miyabara boilers were fitted in 1901 to the protected cruiser Hashidate to replace her original boilers; after that they were used extensively in all classes of naval ships. Nearly contemporaneously with the Miyabara boiler the Navy or "Admiralty" type was also evolved; a "type very similar to the Yarrow boiler, but the tube has a certain curvature," is Admiral Fujii's comment upon it. Turbines attracted Japanese attention at a fairly early date, and in 1907, Messrs. Wm. Denny and Brothers delivered the first of two ferry steamers engined with Parsons turbines. Also in 1906 the battleship Aki and the armoured cruiser Ikoma were launched at Kure and received 7-stage Curtis turbines supplied from America. In the mercantile marine the first steamer to be built in Japan and driven by Parsons turbines (direct-coupled) was the Tenyo Maru, launched in 1907 and built by the Mitsubishi Shipbuilding Company at their Nagasaki shipyard. A little earlier this company purchased the right to manufacture the Parsons turbines, but imported from England those required for the Tenyo Maru, and her sister ship the Chiyo Maru. In a somewhat similar way the name of the Kawasaki Dockyard Company is associated with the manufacture in Japan of the Curtis turbine. More recently Diesel and other internal-combustion engines have received very considerable attention, the three types most in favour being the Vickers, the Sulzer, and the Camellaird-Fullagar; the right to manufacture these engines has been secured by various engineering companies in Japan.

For the education of its future shipbuilders Japan, like this country, has always had the drawing offices of its various establishments, naval and private, as the main fields. In various places technical institutions and night schools have supplied, with more limitations, similar instructions to that provided by such institutions in this country. At their Nagasaki shipyard the Mitsubishi Shipbuilding Company, have a school for the children of their workpeople and the partial education of their apprentices. The Japanese system of education does not allow a boy to go to the University unless he has first passed through a Middle School and then a High School.

The future labour conditions in Japan are going to be no less difficult than elsewhere. Owing to the rush for production during the war, wages rose to an inordinate extent, and as elsewhere the high cost of living has since operated against reduction. The present low value of the yen no doubt makes high wages less of an incubus; on the other hand, neither in steel material nor in wood is the country self-supporting, and the low exchange makes the cost of these and other imports a very serious set-off against the gain in wages. A rather disturbing element also, in labour, only too noticeable during a period of lessening production, is a sort of principle that workmen once employed must receive compensation if discharged. In Japan, as perhaps everywhere, the solution or even partial solution of labour difficulties is a first necessity to the country's prosperity.

* Paper read before the Institution of Naval Architects, London, on April 1, 1925. Abridged.

WAKE PROPELLER COEFFICIENTS.*

By Rear-Admiral D. W. TAYLOR.

THE naval architect would like to have for every ship with which he deals a complete model basin investigation of model resistance and propulsion, as well as the results of an accurately conducted progressive trial. Unfortunately, this is a counsel of perfection, as such information is available for few vessels indeed. For the vast majority of vessels, however, as the result of special trials or service experience there is available fairly reliable information at least of power and revolutions for a single speed at a known displacement and trim. It is the object of this paper to suggest a method for the analysis of such data, deriving a coefficient of propeller performance with the aid of the known results of propeller model tests, and then to demonstrate the use of this coefficient in propeller design, still using to assist us the laws of propeller performance established by model experiment.

The basis of the whole undertaking is the fact that the capacity for power absorption of propellers used in practice may be expressed over a wide range of slip by a formula involving known dimensions and revolutions, and a single coefficient and this wide range of slip includes the slips usually found in practice. If we denote by P the horse-power delivered to a propeller, the shaft, or brake horse-power; by d the diameter of the propeller in feet; by p the face or nominal pitch in feet; by R the revolutions per minute; by s the true slip ratio based upon p; and by C_P a coefficient independent of size called power absorption coefficient; our fundamental formula is :—

$$P = \frac{C_P}{1-s}\left(\frac{p\,R}{1{,}000}\right)^3 \frac{d^2}{p} \quad . \quad . \quad . \quad (1)$$

On the basis of model experiments the coefficient C_P for a given propeller of ellipticalogival type varies but little with slip beyond a slip ratio of 0·20 or so for average propellers. It varies slowly for a given slip as we change proportions such as pitch ratio. If the propeller has blades of abnormal width, C_P for it will increase with slip up to a slip ratio of 0·50 or so. For propellers with abnormally narrow blades, C_P will always fall off as slip increases. For propellers with blades of normal width, C_P will at first increase with slip; then it will reach a maximum, and thereafter decrease slightly with increase of slip. As illustrating this fact, attention is invited to Table I (page 430), of values of C_P over a wide range of slip ratio and pitch ratio for what I call standard three-bladed models.

In a paper read by me in November last before the Society of Naval Architects and Marine Engineers.† there were given composite or average diagrams derived from the published experimental results of Froude, Schaffran, Durand, and myself. It was found that the results given by these experimenters were in sufficient agreement for practical purposes to warrant combining them to form average or composite diagrams. These were prepared without reference to or consideration of C_P, the power absorption coefficient, but upon calculating it the values given in Table I are obtained. Examination of Table I shows that, over the range of actual slip ratios generally used in practice nowadays, C_P varies but little, particularly for the small pitch ratios. We must bear in mind that the slip ratios of Table I refer to the real slip—not the apparent slip. It is evident from Table I that as regards the standard elliptical model we may with adequate approximation characterise its capacity to absorb power by a single value of C_P. Let us designate this standard model value of C_P by S_m.

In Table II are given values of S_m for standard three-bladed elliptical models, over the range of pitch ratios likely to be used in practice. It is noted also on the face of Table II that for the standard elliptical four-bladed model, whose proportions are stated, values of S_m are uniformly 0·15 greater than those for three-bladed models. This seems a simple and adequate approximation as the result of analysis of composite four-bladed diagrams in the paper already

* Paper read before the Institution of Naval Architects, London, on April 2, 1925. Abridged.

† "Comparison of Model Propeller Experiments in Three Nations."

referred to. While Table II refers to models of definite blade outline, blade width, and blade thickness. Analysis of experiments with models having other values of these characteristics indicates that moderate variations of these characteristics have very little effect, so that Table II may be taken as giving with good approximation the power absorption coefficients of models of the vast majority of oval-bladed, ogival-sectioned, uniform-pitch propellers. If we make propellers with very broad tips their power absorption coefficients will go up above those of Table II, but the increase will seldom be as much as 10 per cent. Thick narrow blades will show decidedly higher coefficients on model trials, particularly at fine pitch ratios, but for marine propellers such blades are unimportant.

Equation (1) above, or the equivalent, and the results of systematic model tests as in Table II., or the equivalent, are often used to analyse results of ship trials for the purpose of estimating true slip, and hence the wake. Considering equation (1), we will know from the results of a single trial of a vessel P, p, d, and R, and if we can estimate C_P from the results of systematic propeller model tests, the value of $1 - s$ and hence of s, the true slip, is readily computed. While such analyses are not without value, results are apt to be so erratic as to destroy confidence in the method. It is evident, however, upon consideration that erratic results are to be expected, because it is necessary to make a number of approximations, each involving some error, and there is quite a wide variation possible as errors may chance to be all in one direction, causing maximum positive or negative error, or may chance to oppose one another causing little or no net error.

It is not surprising, therefore, that equation (1), or the equivalent, combined with Table II or the equivalent, will often give erratic and obviously erroneous results for true slip. It may be reasonably argued that for purposes of propeller design we can usually get along without knowing the true slip accurately, but without pursuing this line consider a modified equation not involving slip explicitly.

If V denote ship speed in knots with reference to undisturbed water, V_A the speed of advance of the propeller in knots with reference to the assumed uniform wake in which it works, and w the wake fraction or $\frac{V - V_A}{V}$, we have :—

$$101\tfrac{1}{3}\,V\,(1-w) = 101\tfrac{1}{3}\,V_A = p\,R\,(1-s) \quad . \quad (2)$$

Multiplying corresponding sides of equations (1) and (2) we have :—

$$101\tfrac{1}{3}\,P\,V\,(1-w) = C_P\left(\frac{R}{100}\right)^4 100\,\frac{p^5 d^5}{1{,}000}$$

we must be able to estimate the W_P of a new design. The best line to take in this connection is to make use of coefficients from previous vessels resembling as closely as possible the new design as regards size, fullness, propeller type, and relative propeller positions. From data of speed, power, and revolutions obtained with reasonable care for a vessel in service, values of W_P are readily calculated. A single value from a single vessel is liable to mislead us, but a group of values obtained from the results in service of a number of vessels resembling each other in type, will give a thoroughly reliable average result. Such data are not always available ; but even from data for

in connection with propeller design, let us revert to our basic formula, equation (3).

$$W_P = \frac{1{,}000\,P\,V}{S_m\,d^5\,p^5\left(\frac{R}{100}\right)^4}$$

Put into another form this becomes :—

$$d\,p = 10\left[\frac{P\,V}{W_P\,S_m\left(\frac{R}{100}\right)^4}\right]^{\frac{1}{5}} \quad . \quad . \quad (4)$$

Now in any normal given case the propeller designer will have estimates of P, V, and R. With an appro-

TABLE I.

Varying values of the power absorption coefficient — C_P, for various slip ratios and pitch ratios of three-bladed standard elliptical model propellers. Mean width ratio = 0·25. Developed area ÷ disc area = 0·382. Blade thickness fraction = 0·05.

Slip Ratio.	0	0·05	0·10	0·15	0·20	0·25	0·30	0·35	0·40	0·45	0·50
Pitch Ratio.	*Values of C_P.*										
0·6	2·52	2·53	2·62	2·75	2·70	2·68	2·66	2·59	—	—	—
0·7	1·95	2·11	2·26	2·37	2·43	2·50	2·50	2·43	2·38	2·30	2·14
0·8	1·66	1·87	2·04	2·18	2·26	2·32	2·34	2·31	2·25	2·20	2·11
0·9	1·46	1·68	1·87	2·03	2·12	2·20	2·22	2·22	2·19	2·14	2·09
1·0	1·31	1·56	1·76	1·90	2·01	2·10	2·12	2·13	2·10	2·08	2·06
1·1	1·21	1·50	1·69	1·82	1·92	2·02	2·05	2·06	2·05	2·03	2·03
1·2	1·16	1·42	1·60	1·75	1·84	1·94	1·98	2·00	1·99	1·97	1·98
1·3	1·11	1·38	1·56	1·70	1·80	1·87	1·90	1·94	1·96	1·94	1·95
1·4	1·07	1·33	1·52	1·67	1·75	1·81	1·88	1·89	1·95	1·91	1·90
1·5	1·05	1·31	1·49	1·63	1·72	1·79	1·86	1·86	1·89	1·92	1·88
1·6	1·11	1·29	1·47	1·60	1·70	1·77	1·82	1·86	1·86	—	—
1·7	1·04	1·26	1·44	1·58	1·68	1·74	1·80	1·83	1·84	—	—
1·8	1·02	1·24	1·43	1·56	1·65	1·71	1·77	1·81	1·82	—	—
1·9	1·02	1·21	1·42	1·54	1·64	1·69	1·74	1·78	1·80	—	—
2·0	1·01	1·21	1·42	1·53	1·63	1·65	1·73	1·78	1·78	—	—

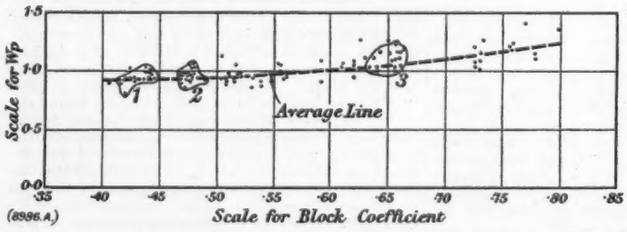
TABLE II.

Standard values of S_m—model power absorption coefficient—for varying pitch ratios of three-bladed standard elliptical model propellers. Mean width ratio = 0·25. Developed area ÷ disc area = 0·382. Blade thickness fraction = 0·05.

Pitch Ratio.	0	0·01	0·02	0·03	0·04	0·05	0·06	0·07	0·08	0·09
0·6	2·64	2·62	2·60	2·58	2·56	2·54	2·53	2·51	2·49	2·48
0·7	2·46	2·45	2·43	2·41	2·40	2·39	2·37	2·36	2·35	2·33
0·8	2·32	2·31	2·29	2·28	2·27	2·26	2·25	2·24	2·23	2·22
0·9	2·21	2·20	2·19	2·18	2·17	2·16	2·15	2·14	2·13	2·12
1·0	2·12	2·11	2·10	2·09	2·08	2·08	2·07	2·06	2·05	2·05
1·1	2·04	2·03	2·03	2·02	2·01	2·01	2·00	1·99	1·99	1·98
1·2	1·98	1·97	1·97	1·96	1·96	1·95	1·95	1·94	1·94	1·93
1·3	1·93	1·92	1·92	1·91	1·91	1·90	1·90	1·90	1·89	1·89
1·4	1·88	1·88	1·88	1·87	1·87	1·87	1·86	1·86	1·86	1·85
1·5	1·85	1·85	1·84	1·84	1·84	1·83	1·83	1·83	1·83	1·82
1·6	1·82	1·82	1·82	1·81	1·81	1·81	1·81	1·80	1·80	1·80
1·7	1·80	1·80	1·79	1·79	1·79	1·79	1·79	1·78	1·78	1·78
1·8	1·78	1·78	1·77	1·77	1·77	1·77	1·77	1·77	1·76	1·76

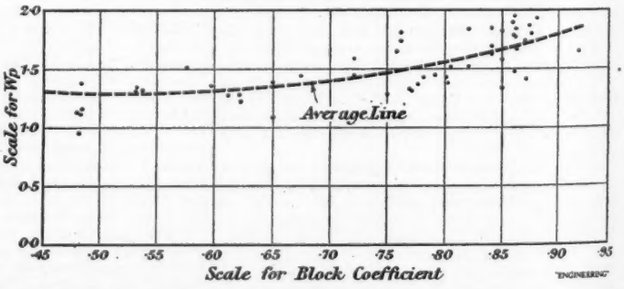
Add to above 0·15 to obtain standard values of S_m for four-bladed standard elliptical model propellers of mean width ratio = 0·20, blade thickness fraction = 0·04, and developed area ÷ disc area = 0·407.

Fig. 1. VALUES OF W_P FOR 100 TWIN SCREW VESSELS
GROUP 1-15 1000 TO 1100 TON U.S. DESTROYERS
GROUP 2-21 1200 TO 1300 TON U.S. DESTROYERS
GROUP 3-17 OLD U.S. BATTLESHIPS



(8996.A.)

Fig. 2. VALUES OF W_P FOR 50 SINGLE SCREW VESSELS.



For present purposes we may ignore the difference between $101\frac{1}{3}$ and 100, allowing it to be taken account of in our coefficient values. Also, in order to allow us to use model results, let us put $C_P = kS_m$, where S_m is the value of C_P for the standard model (Table II), and k is a coefficient which expresses all the discrepancies pointed out above. Then, finally, denote $\frac{k}{1-w}$ by W_P, where W_P is a coefficient that will be called the wake propeller coefficient.

Reducing the equation above, after the substitutions, &c., indicated, we arrive finally at :—

$$W_P = \frac{1{,}000\,P\,V}{S_m\,d^5\,p^5\left(\frac{R}{100}\right)^4} \quad . \quad . \quad (3)$$

Now if equation (3) correctly expresses physical facts, W_P, apart from unavoidable errors, can vary but little with speed in the case of a given ship, since we have reason to believe that w does not vary greatly with speed in a given case, and k should not vary appreciably unless cavitation is present. So we can obtain a fair check upon the soundness of equation (3) by determining from it the values of W_P for vessels of various types over the speed range in each case covered by an accurate speed trial.

In order to make use of wake propeller coefficients, a number of miscellaneous vessels we can establish averages that will be useful in the absence of preferable similar vessel data. Figs. 1 and 2 show by dots the wake propeller coefficients of one hundred twin-screw vessels and fifty single-screw vessels, rather arbitrary average lines being indicated. The coefficients are plotted upon block coefficients. It is recognised that the block coefficient is not the best basis for plotting wake—the major element in W_P—but we know that in practice wake does increase with block, and the block coefficient is nearly always available, while longitudinal and vertical prismatic coefficients are not known without rather full information concerning the vessel.

The information to plot Figs. 1 and 2 was obtained from various sources, and all sorts of spots are shown—good, bad, and indifferent. A few spots are very erratic. They are probably capable of explanation if all the facts were known ; but it will be observed that the vast majority of spots come within 10 per cent. of the mean. This, it will be seen later, is an adequate approximation for usual cases of propeller design. The majority of the twin-screw spots and many of the single-screw spots refer to vessels of the U.S. Navy. The single-screw spots for very full blocks nearly all refer to vessels of the Great Lakes of America.

Coming now to the use of wake propeller coefficients

priate estimate of W_P everything on the right-hand side of equation (4) is known except S_m. It is often a very simple procedure to estimate from previous experience the desirable apparent slip ratio, s', say. Then $p = \frac{101\frac{1}{3}\,V}{R\,(1-s')}$, and, with p fixed, S_m can be readily approximated to and d calculated by one or two successive approximations.

However, in general it is highly advisable to handle matters in such a way that the designer may make his final choice of dimensions after he has had an opportunity to consider fully the effect of dimensions upon efficiency. This requires exploration of the whole field of possible dimensions. Suppose we denote pitch ratio p/d by a. Then $p = a\,d$. Upon substituting this in (4) and reducing, we have :—

$$d = \left(\frac{10}{a}\right)^{\frac{1}{2}}\left[\frac{P\,V}{W_P\,S_m\left(\frac{R}{100}\right)^4}\right]^{\frac{1}{5}} \quad . \quad (5)$$

In the above when we give a value to a, we also fix S_m (Table II). Then everything on the right-hand side of equation (5) is known, and with the aid of a table of squares and cubes, d is readily calculated for any desired number of values of pitch ratio, a, remembering that the sixth root of a number is the square root of its cube root.

Now (5) gives us all possible combinations of diameter and pitch, but tells us nothing about efficiency. To explore the efficiency field we again have recourse to results of model experiment. The composite diagrams already referred to for standard model propellers included curves of efficiency. For the purposes of the paper in which they were included the efficiency curves were plotted upon values of $\frac{R\sqrt{P}}{V_A 2\frac{1}{2}}$. For present purposes they must be reduced to a different basis not involving V_A. Many such expressions have been used and are available, but the most suitable one appears to be :—

$$\frac{P}{d^2\left(\frac{P\,R}{1{,}000}\right)^3}$$

which may, perhaps, be called the "power diameter revolution coefficient." From Fig. 3 or 4 as appropriate, for the correct values of

$$\frac{P}{d^2\left(\frac{P\,R}{1{,}000}\right)^3}$$

we can find upon the corresponding pitch ratio efficiency curves the relative efficiencies, and are then in a position to plot upon pitch ratio curves of diameter, pitch, and relative efficiency.

Three complete calculations, all referring to a 10,000-ton deadweight tanker, and for P = 2,208, R = 76, and V = 11 were made. For one calculation W_P has its actual value of 1·40. For the other two W_P is 1·19 and 1·61, or 15 per cent. below and above the actual value. From the results obtained, Fig. 5 was plotted, showing for the tanker under the three assumptions with respect to W_P, curves of diameter, pitch and efficiency. Of course, strictly speaking, it is incorrect to take P constant and deduce varying efficiency. The useful power is constant, and P is different for each different efficiency. But P is an approximation in any case. The result of taking it constant is simply that the propellers determined by assuming it constant will absorb the real powers, P, with minor differences of revolution, slip and efficiency from those of Fig. 5. We could arrive at closer theoretical results by correcting our P values by Fig. 5, and making a second approximation, but this is not necessary for practical cases where P nearly always contains a liberal margin.

Fig. 5 requires little comment. Bearing in mind that we are dealing with quantities and coefficients that are necessarily approximate, we would like to know in a general way the effect of normal errors upon our results. We saw from Figs. 1 and 2 that we should usually be able to estimate W_P within 10 per cent., so a variation of 15 per cent. above and below should cover all cases.

Considering maximum efficiencies only, we have the results given in the next column.

This shows quite a variation of diameter and pitch. But suppose, instead of aiming at absolutely the maximum efficiency, we determine dimensions when the efficiency is one point of percentage only below the maximum. In each case there will be two spots

	Diameter.	Pitch.
	Ft.	Ft.
W_P normal	18·4	15·1
W_P 15 per cent. small	17·3	17·3
W_P 15 per cent. large	18·8	13·6

on an efficiency curve 0·01 below the maximum, so for each W_P there will be two corresponding values of diameter and pitch. Results are tabulated below, the large diameter corresponding to the lower pitch ratio being given first in each case :—

	Diameter.	Pitch.	Diameter	Pitch.
	Ft.	Ft.	Ft.	Ft.
W_P normal	19·45	14·0	16·9	16·9
W_P 15 per cent. small	18·9	15·6	16·05	19·1
W_P 15 per cent. large	19·7	13·0	17·75	14·9

The above shows that in this case the propeller designer has a very wide range of diameters available, within which he can reach substantially the maximum efficiency possible with the W_P value of the case. Broadly speaking, this is true generally, as is the converse proposition that, no matter how he may ring the changes of diameter, pitch, blade area, and blade shape, the designer, when cavitation is not to be provided against, cannot produce a propeller efficiency beyond a limit fixed by extraneous conditions such as wake fraction, thrust deduction and revolutions. We see in Fig. 5 that the attainable propeller efficiency varies materially with the value of W_P, which means virtually the value of the wake fraction. Once wake fraction, thrust deduction and revolutions are fixed, a designer, design he never so well, is surrounded by barriers to efficiency which, so far as our present knowledge goes, are insurmountable by variations of propeller design. Real gain in propulsive efficiency, which involves not only the propeller efficiency we have been considering, but also the hull efficiency factor, has to be sought through control of wake fraction and thrust deduction, and the adoption of revolutions which enable the power to be efficiently developed at the speed of the ship. It appears that for single-screw ships we gain some mitigation of thrust deduction by raking propeller blades aft; but with this exception the wake fraction and thrust deduction depend primarily upon the hull and the position of the propeller, and the possible gain in propulsive efficiency by modifying the hull is much greater than that possible through propeller design.

As regards revolutions, practically every consideration except that of propeller efficiency is on the side of the small, high-revolution propeller. For the case of the tanker above, for the actual value of W_P, the maximum propeller efficiency at 76 r.p.m. is seen from Fig. 5 to be 0·60. It will be found that, following the same methods the maximum propeller efficiencies at 60 and 100 r.p.m. are 0·63 and 0·57 respectively. This is a variation of 6 points, or 10 per cent. of the

Fig. 3. EFFICIENCIES OF 3 BLADED STANDARD MODEL PROPELLERS PLOTTED UPON VALUES OF $\frac{P}{d^2\left(\frac{pR}{1000}\right)^3}$

P Denotes Power Delivered to Propeller. *p Denotes Propeller Pitch in Feet.*
d Denotes Propeller Diameter in Feet. *R Denotes Propeller Revolutions per Minute.*

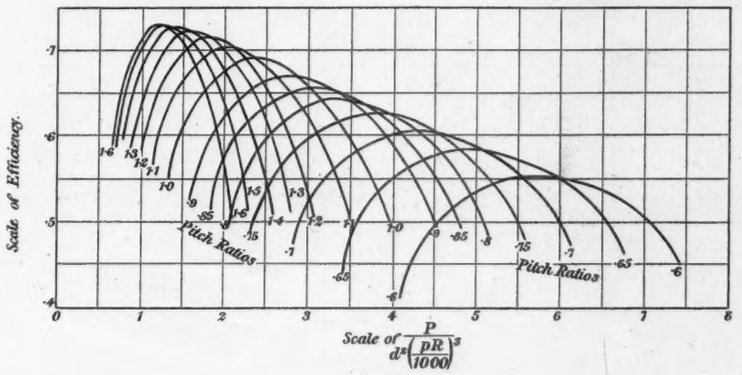


Fig. 4. EFFICIENCIES OF 4 BLADED STANDARD MODEL PROPELLERS PLOTTED UPON VALUES OF $\frac{P}{d^2\left(\frac{pR}{1000}\right)^3}$

P Denotes Power Delivered to Propeller. *p Denotes Propeller Pitch in Feet.*
d Denotes Propeller Diameter in Feet. *R Denotes Propeller Revolutions per Minute.*

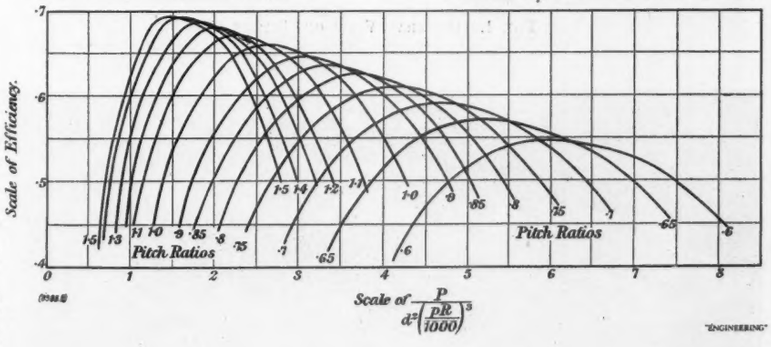
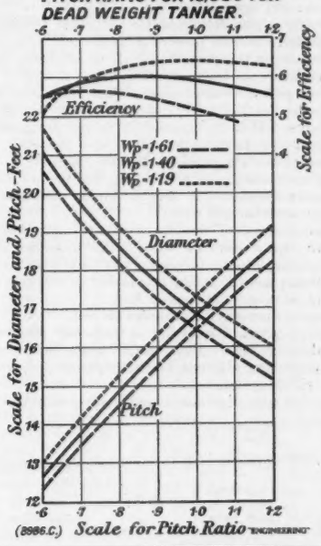


Fig. 5. CURVES OF DIAMETER, PITCH AND EFFICIENCY PLOTTED ON PITCH RATIO FOR 10,000 TON DEAD WEIGHT TANKER.



This is independent of size—mathematically dimensionless for constant density of water—and can be deduced from the expression $\frac{R\sqrt{P}}{V_A 2\frac{1}{2}}$. Thus, if we have $\rho = \frac{R\sqrt{P}}{V_A 2\frac{1}{2}}$ we have :—

$$\frac{P}{d^2\left(\frac{P\,R}{1{,}000}\right)^3} = 0{\cdot}09359\, a^2 \rho^2 (1-s)^5 \quad . \quad (6)$$

Upon making the transformation by means of equation (6) we obtain data to plot the efficiency curves of Figs. 3 and 4 referring to three-bladed and four-bladed standard models. While the actual efficiencies indicated in Figs. 3 and 4 refer, of course, to the standard models only, the curves can be used with a good deal of confidence as representing relative efficiencies of all kinds of propellers.

Having, then, the curves of Figs. 3 and 4, the further procedure is obvious. Starting with our values of P, R, V, and W_P, by the use of equation (5) calculate for various values of a the values of d and p. Then for each value of a and corresponding d and p, calculate resulting values of

$$\frac{P}{d^2\left(\frac{P\,R}{1{,}000}\right)^3}$$

original propeller efficiency for a practicable variation of revolutions, and the variation of propulsive efficiency, while not exactly the same, would be about the same. Of course, the most desirable design is not necessarily the one with the maximum propulsive efficiency. First cost, weight, and many other considerations come in, but the designer should be in a position to know just how he stands with regard to propulsive efficiency before making his final choice.

In concluding, I desire to record my indebtedness to the Bureau of Construction and Repair of the U.S. Navy Department, and to Dr. Herbert C. Sadler, Head of the Department of Naval Architecture of the University of Michigan, U.S.A., for data made use of in this paper.

APPENDIX.

SYMBOLS AND FORMULÆ.

The symbols used throughout the paper, their definitions and formulæ are collected below :—

P denotes power delivered by the shaft to the propeller. When power is measured by torsionmeter on the propeller shaft (shaft horse-power, S.H.P., or brake horse-power, B.H.P.), P is the power so measured. When indicated horse-power—I.H.P.—is determined, P is derived from I.H.P. by deducting from the latter the power that does not reach the propeller, such as power absorbed by friction, pumps, &c.

R denotes revolutions of the propeller per minute.

V denotes speed of the ship in knots with reference to undisturbed water.

V_A denotes speed of the ship in knots with reference to the water in which the propeller works, assumed to be following the ship with uniform wake velocity. V_A is usually called the speed of advance of the propeller.

d denotes diameter of propeller in feet.

p denotes pitch of propeller in feet—the pitch of the driving face. This pitch is uniform for the propellers referred to in the paper, except the Iris propellers.

s denotes true slip ratio based upon p and V_A.

$$\text{Formula } s = \frac{p\,R - 101\frac{1}{3}\,V_A}{p\,R}$$

s' denotes apparent slip ratio based upon p and V.

$$\text{Formula } s' = \frac{p\,R - 101\frac{1}{3}\,V}{p\,R}$$

a denotes pitch ratio.

$$\text{Formula } a = \frac{d}{p}$$

Mean width ratio denotes ratio between mean width of blade and diameter of propeller.

Blade thickness fraction denotes ratio between axial thickness if central radial section is extended to axis and diameter d.

w denotes wake fraction or ratio between forward velocity of assumed uniform wake and speed of ship.

$$\text{Formula } w = \frac{V - V_A}{V}$$

C_P denotes a coefficient independent of size, called power absorption coefficient.

$$\text{Formula } C_P = \frac{p\,P\,(1-s)}{d^3\left(\frac{p\,R}{1{,}000}\right)^3}$$

S_m denotes value of C_P for standard three-bladed and four-bladed models.

ρ denotes a dimensionless coefficient.

$$\text{Formula } \rho = \frac{R\sqrt{P}}{V_A^{\,2\frac{1}{2}}}$$

k denotes a coefficient expressing the ratio between C_P for an actual propeller and S_m for a standard model propeller of same diameter and pitch.

$$\text{Formula } C_P = k\,S_m$$

W_P denotes wake propeller coefficient.

$$\text{Formula } W_P = \frac{k}{1-w}$$

VULCAN TWO-TON LORRY CHASSIS.

THE 2-ton lorry chassis of the Vulcan Motor and Engineering Co. (1906), Limited, of Southport, which we illustrate in Figs. 1 to 4, on this page and opposite, is one of the first vehicles designed to the War Office No. 11 Specification to pass the necessary tests to render it eligible for the subsidy, and it is of particular interest for this reason. Under the War Office scheme a subsidy of 120*l.*, extending over a period of three years, is payable to the owner of an approved vehicle, and in our issue of July 25, 1924, we referred to the importance of the scheme from a national standpoint. In the same article we dealt with the chief features of the specification, and we may, therefore, proceed at once to a description of the Vulcan chassis. The engine, which follows conventional lines, is of the four-cylinder monobloc type, 3·74-in. bore by 5·111-in. stroke (95 mm. by 140 mm.), giving a cubic capacity of 3,965 c.c. and 22·4 R.A.C. rating. The engine actually develops 28·8 brake horse-power at 1,000 r.p.m., and 39 brake horse-power at 1,400 r.p.m. The head is detachable, four lugs at the corners being provided for lifting purposes. The cylinder block and head are of cast-iron, but the water outlet pipe, which is

TWO-TON SUBSIDY LORRY.

THE VULCAN MOTOR AND ENGINEERING COMPANY (1906), LIMITED, SOUTHPORT.

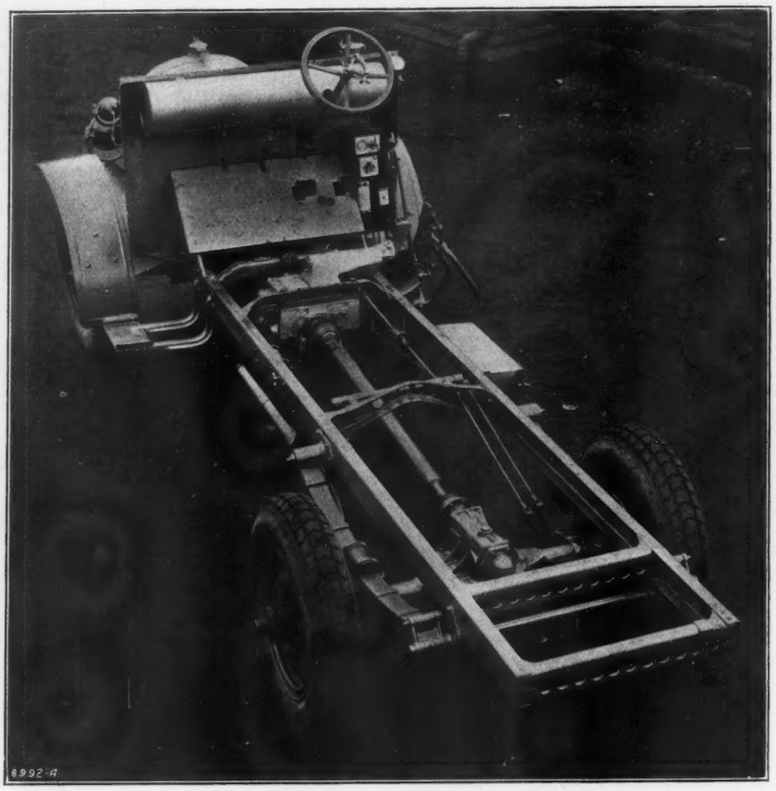


FIG. 1. GENERAL VIEW OF CHASSIS.

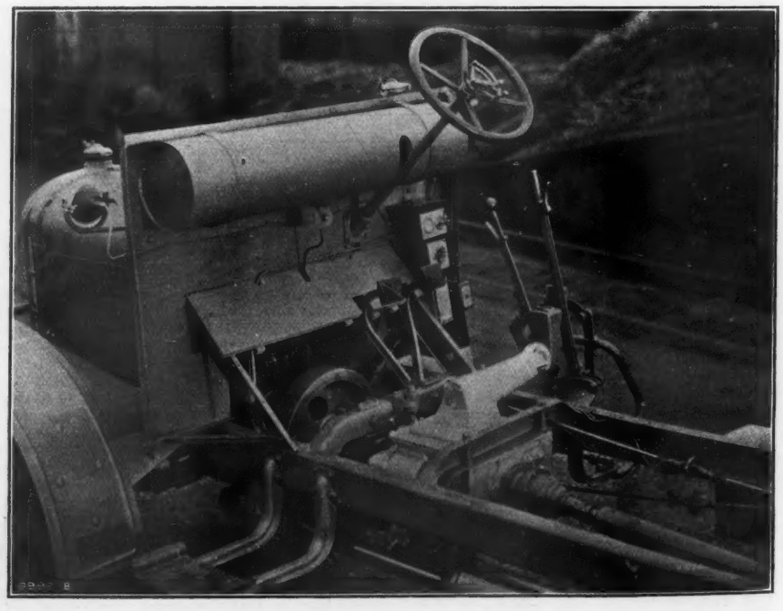


FIG. 2. CONTROLS AND DASH BOARD.

TWO-TON SUBSIDY LORRY.

THE VULCAN MOTOR AND ENGINEERING COMPANY (1906), LIMITED, SOUTHPORT.

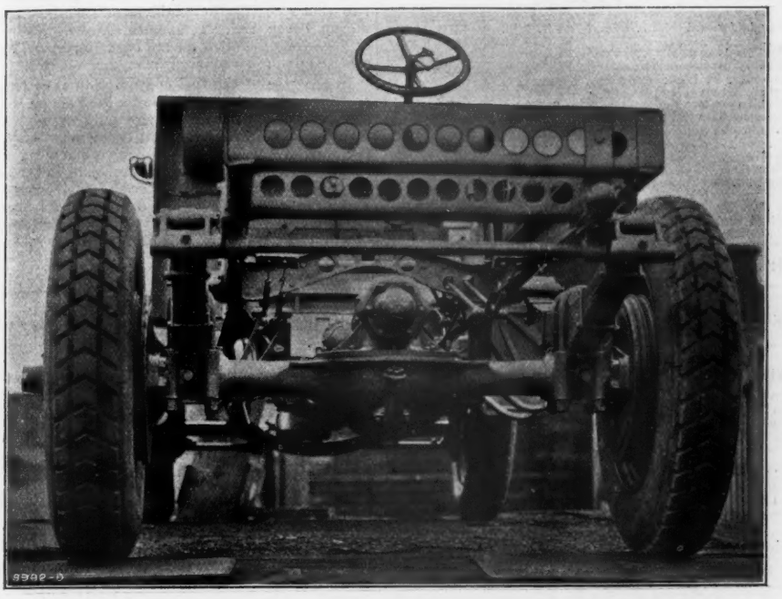


FIG. 3. REAR VIEW.

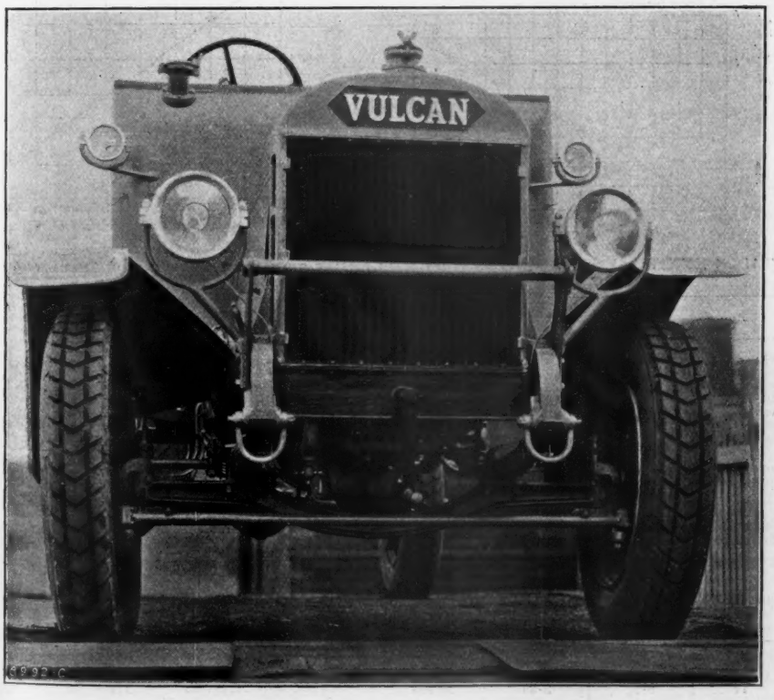


FIG. 4. FRONT VIEW.

bolted to the head, is an aluminium casting. The crank-case is also of the latter metal, and is fastened to the cylinder block by the main bearing bolts, which are extended through the case. The engine unit is supported at three points to ensure freedom from the effects of frame distortion. The valves are of 3 per cent. nickel steel, having a throat diameter of 2 in., and are operated by roller tappets of large diameter. They operate in a chamber which is fed with an oil mist from the crank-case, the chamber cover being held on by two wing nuts, which are in an easily accessible position. The camshaft is of C.N.Y. steel, and is of substantial size to ensure quiet running. It is supported by three bearings lubricated by pressure feed. The pistons are of aluminium alloy, with 1-in. diameter case-hardened steel gudgeon pins, and the connecting rods are 40-ton steel stampings, fitted with a bronze bush at the small end. The crankshaft is also a 40-ton steel stamping, fitted with a double thrust washer to take end thrust. The crank-pin and main bearings are both 2½-in. diameter, the bearings being of bronze backed with white metal liners. It will be remembered that the War Office specification calls for the examination of the big end and main bearings, including the removal and replacement of all caps, to be effected in five hours, and to facilitate this process in the Vulcan engine the bottom half of the crank-case can be removed without taking the engine from the chassis. The camshaft and magneto are driven by a triangular silent chain drive, and in accordance with the specification provision is made for chain adjustment by means of a jockey pulley running on ball bearings, the fixing of the jockey pulley being such that the chain drive is not disturbed when the timing cover is removed. A Zenith horizontal type carburettor is bolted direct to the off side of the cylinder block, the mixture, passing through a passage cast in the block, to the induction pipe, which is mounted on the near side of the engine below the exhaust manifold, the latter being ribbed in the usual way. The magneto is bolted on a platform on the off side of the crank-case parallel to the crankshaft, and is connected to the magneto driving shaft by a Simms coupling. The water pump is in a somewhat unusual position, as it forms a combined unit with the fan. The gland is thus in a very convenient position for adjustment. Lubrication is by a gear-type pump submerged in the sump, and driven by skew gears from the camshaft. The main bearings, big end bearings, camshaft bearings and chain drive are all lubricated from this pump. A suction filter in the sump is arranged in such a position that it may be withdrawn for cleaning purposes without losing the main body of oil in the crank chamber. A pressure filter is also fitted on the near side of the crank-case.

Turning now to the transmission, the clutch, which can be clearly seen in Fig. 2, is of the direct cone type, lined with Ferodo. It is fitted with adjustable springs, which can be seen in the illustration, and is provided with a clutch stop. The flywheel is of cast-iron. A flexible fabric joint connects the clutch to the gear box, and is designed so that the clutch may be withdrawn without dismantling either the engine or gear-box. The latter is made of aluminium and is suspended at three points, with a view to protecting it from the effects of frame distortion. The method of mounting can be seen in Figs. 1 and 2. Four speeds and reverse are provided, the forward ratios being 7 to 1, 11·9 to 1, 18·34 to 1 and 31·22 to 1, the reverse ratio being 40 to 1. The stub tooth gears are mounted on large diameter shafts running on ball bearings. As will be seen from Figs. 1 and 2, a right-hand gate change is fitted with a safety reverse catch on the change-speed lever. The change-speed mechanism is mounted entirely on the gear-box, and cannot, therefore, be affected by frame distortion. The selector forks have a positive lock, so that only one gear can be engaged at a time. A breather is placed on the filler cover and an oil-level cock on the side of the case. Hotchkiss transmission is employed, the universal joints at both ends of the propeller shaft being of the Spicer type, completely cased in, the casings being partly filled with soft grease. The rear axle, shown in Fig. 3, is of the full floating type, and consists of a one-piece 40-ton pot type steel stamping, carrying the overhead worm and wheel reducing gear, and also the bevel differential, in a separate housing, which can be removed without disturbing the axle-casing. The worm shaft runs on ball bearings, and a double-thrust washer is provided to take end thrust. The worm reduction is 7 to 1. The road-wheel shafts are of 100-ton steel, and are mounted on hubs running on large diameter roller bearings. Both hand and foot brakes operate on the rear wheels, and as will be seen from the illustration, are of the internal expanding type, with ribbed drums. The shoes are Ferodo lined. The front-axle, shown in Fig. 4, is a 40-ton steel stamping of I section, with hubs running on ball bearings. The same view shows the radiator, which follows the specification in being of the straight tube type, with detachable top and bottom tanks. The tubes are of $\frac{5}{16}$-in. bore, and the total capacity of the radiator is 8 gallons. Both the overflow pipe and the drain cock are of ½-in. bore, the latter being fitted in such a position that the water system can be completely drained. A strong bar is fitted across the front of the radiator to minimise the danger of accidental damage, and the requirement regarding the temperature regulation is met by the provision of a three-ply board to be used when necessary. This appears a somewhat makeshift arrangement on an otherwise excellent chassis. Steering is by a case-hardened worm and bronze wheel mounted in a box supported on the frame member. The worm shaft is mounted on ball bearings and the worm is provided with single ball-thrust washers at both ends. The frame is of 3 per cent. nickel steel, the side members being 5 in. deep, and inswept at the front. It will be observed from the various illustrations that the cross members are lightened by drilling, with the exception of those carrying the gear-box. Both front and rear springs

are of the semi-elliptic type. The petrol tank, which can be seen in Figs. 1 and 2, is mounted on the rear of the dash, the feed being by gravity. A two-way cock is fitted giving a 2½-gallon emergency supply. Both petrol tank and radiator caps are of the non-detachable type. The overall length of the chassis is 17 ft. 2½ in., the overall width 9 ft. 2 in., the wheelbase 11 ft. 5 in., and the front and rear tracks 4 ft. 10 in. and 4 ft. 8 in. respectively. The minimum ground clearance is 11 in., the chassis weight is 34½ cwts, the net load capacity 2 tons, and the fuel consumption 1 gallon to 13 miles.

MARINE OIL ENGINE TRIALS.

(*Concluded from page* 402.)

THE trials at sea of the T.S.M.S. Dolius were carried out in the Firth of Clyde on Wednesday and Thursday, April 2 and 3, 1924. On both days of the trials the vessel had on board some 2,582 tons of stores, fuel and water ballast, the draught being then 12 ft. 1½ in. forward and 18 ft. 6 in. aft. In Table XXVI are shown particulars, provided by the ship-builders, of the co-efficients, displacements, &c., for both the fully-loaded and the trial conditions.

TABLE XXVI.

—	Load Condition.	Trial Condition.
Draught forward	25 ft. 9 in.	12 ft. 1½ in.
„ Aft	25 ft. 9 in.	18 ft. 6 in.
Total displacement	11,533 tons	6,382 tons
Moulded displacement (excludes bossing, 93 tons; excludes shell, 85 tons at load draught)	11,415 tons	6,288 tons
Block co-efficient (on moulded displacement and dimensions)	0·7486	0·6590
Midship area (moulded)	1291·90 sq. ft.	748·83 sq. ft.
„ „ co-efficient (moulded)	0·9682	0·9460
Prismatic co-efficient (moulded)	0·7732	0·7348
Wetted surface (moulded)	33,709 sq. ft. 674 „	24,016 sq. ft. 674 „
Wetted surface, total, including all appendages	34,383 sq. ft.	24,690 sq. ft.

The ship was three days out of dock and the bottom was freshly painted. The wind and sea conditions throughout the trials were good, and all parts of the programme were carried through satisfactorily.

The measured mile trials were carried out off Skelmorlie and were arranged thus :—

4 runs at nominal engine speed of 130 r.p.m.
4 „ „ „ 120 „
2 „ „ „ 105 „
2 „ „ „ 85 „

The foregoing runs are numbered 1 to 12 in the tabulations of the results. In the case of each speed above, the consecutive runs were made alternately up and down the stream in order to cancel the effect of tide, &c. The fuel consumption trials were arranged thus: Between Skelmorlie and Ailsa Craig, 4 hours run at nominal engine speed of 105 r.p.m. and between Ailsa Craig and Greenock, 3½ hours' run at nominal engine speed of 130 r.p.m. This pair of runs are referred to in the tables as Nos. 13 and 14 respectively, and the observations and deductions are recorded along with those of Run Nos. 1 to 12, in the tabulated results. Particulars of the courses, the wind, ship speeds and revolutions per minute of the engines are recorded in Table XXVII.

Throughout the trials the sea was smooth. The wind velocity never exceeded 8 knots on the first day; during the first eight runs, it was opposed to the ship on the even numbered runs, but died out about Run Nos. 9 and 10, and became merely a light breeze opposing the ship during Run No. 11 and favouring the ship on Run No. 12. On the second day the wind was negligible during both trials.

During the measured mile runs, two Walker logs were trailed from aft, so that the fish were on the outer edges of the propeller wake; readings of these logs enabled the corrections necessary to obtain the true speed from the log record to be derived. On the long runs to and from Ailsa Craig, the log mileage was observed at close intervals and a curve of speed on a time base was plotted. The average height of this curve plotted over the period of each trial and duly corrected in respect of the calibration data obtained on the measured mile runs has been taken as the mean speed. The speeds obtained by direct timing over the measured mile, and by log for the consumption runs, are recorded in Table XXVII. In the case of the measured mile runs (Runs 1 to 12), the revolutions made by each engine were recorded when the signal was received from the bridge that the vessel was passing the line of posts on entering on the mile course and again on leaving, as well as at intermediate one-minute intervals. The level of the fuel in the measuring tank from which the port engine drew its supply, was observed at one minute intervals from the time that the vessel had been put on a straight course before entering the mile, and the observations were maintained until the vessel was turned out of her course on its completion. It was possible to obtain two sets of indicator cards from each main engine during every run. Temperatures, &c., about both engines were recorded during each run made, as were other engine-room observations.

In the case of the fuel consumption runs (Runs 13 and 14), the revolutions made by each engine, and the level of the fuel in the service tank supplying both main engines and the electric-generator engines in use, were observed every half-hour, when also indicator cards were taken and other observations in the engine-room were recorded. The speed of each main engine was arranged so that the average revolutions per minute should be as near as possible to the respective nominal revolutions. For the measured mile trials, the controls (fuel and steam) of each engine were unaltered for the successive runs at any given nominal revolution per minute, once the required speed had been attained.

The temperatures (approximate) in the engine room were observed to be as follows :—

	On April 2. deg. F.	On April 3. deg. F.
At Starting platform	65	67
At middle platform	82	73

The fuel consumptions are recorded in Tables XXXIVA and XXXIVB. The exhaust gases from both main engines, the generator engines, and the boilers when in use, were led separately to the top of the main funnel, but it was impossible to observe definitely the colour of the gases from the main engines. Observations of the lubrication of the main engines showed that the pressure of supply of oil to the crank-case was between 8 lb. and 10 lb. per square inch; and that the daily consumption of lubricant in the cylinders of both main engines, when running at 130 r.p.m. (nominal) was 7¼ gallons.

For the purposes of the measured mile trials (Run Nos. 1 to 12) the pair of calibrated tanks which were

TABLE XXVII.—SHIP AND ENGINE SPEEDS.

Nominal revolutions of engines Wind, velocity and direction	130 8 Knots from South.				120 7 Knots from South.				105 None.		85 7 Knots from North.		105 None.	130 None.
Run number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Time of day	a.m. 11.35	p.m. 12.2	p.m. 12.25	p.m. 12.55	p.m. 1.20	p.m. 1.45	p.m. 2.10	p.m. 2.35	p.m. 3.0	p.m. 3.30	p.m. 4.0	p.m. 4.35	a.m. p.m. 10.15–2.15	p.m. p.m. 2.45–6.15
Direction of run	North	South	North	South	North	South	North	South	North	South	North	South	South	North
Ship's speed, knots	12·37	12·25	12·13	12·51	11·15	11·61	11·05	11·59	9·71	10·30	7·62	8·41	10·00	12·00
Mean of means, or mean for runs, knots	12·25				11·34				10·00		8·02		10·00	12·00
Revolutions per minute :—														
Port engine	133·5	132·0	133·1	134·2	123·0	121·4	122·6	122·2	107·0	106·1	85·3	87·0	105·9	128·4
Starboard engine	132·7	131·8	131·7	132·7	122·3	120·7	121·8	120·8	104·7	105·0	83·5	84·7	105·3	128·4
Average, both engines	133·1	131·9	132·4	133·4	122·7	121·0	122·2	121·5	105·9	105·5	84·4	85·9	105·6	128·4
Mean of means, or mean for runs :—														
R.P.M. Port engine	132·9				122·1				106·5		86·1		105·9	128·4
R.P.M. Starboard engine	132·0				122·1				104·9		84·1		105·3	128·4
R.P.M. Average, both engines	132·5				122·1				105·7		85·1		105·6	128·4

TABLE XXXIII.—*Fuel Consumption.*

Run Number.	13		14	
	Lb. per Hour.	Tons per Day.	Lb. per Hour.	Tons per Day.
For—				
All purposes (observed)	485·0	5·19	785·9	8·42
Generator engines (estimated)	100·5	1·08	85·1	0·91
Both main engines (difference)	384·5	4·11	700·8	7·51

Fig.30. TRIALS AT SEA; FUEL PER MINUTE—INDICATED HORSE-POWER.

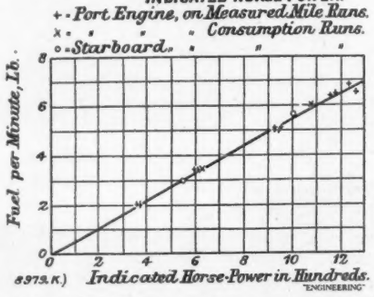


Fig.32. VARIATION OF SPECIFIC GRAVITY OF FUEL OIL WITH TEMPERATURE.

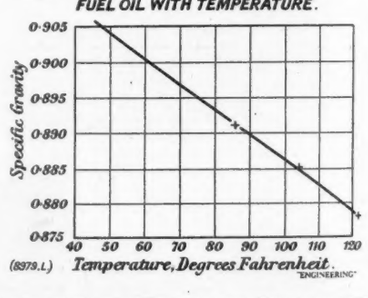


TABLE XXXIVA.—FUEL CONSUMPTION (PORT MAIN ENGINE ONLY); AND TORQUE FROM CHARACTERISTIC DIAGRAM (FIG. 21, PAGE 400 *ante*).

Run Number :	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fuel per minute lb.	6·52	6·37	6·45	6·88	4·98	5·00	5·05	5·09	3·40	3·39	2·00	1·99	3·44	6·06
Fuel per minute (corrected to fair line, Fig. 30, and for calorific value)	6·72	6·18	6·28	6·55	5·01	4·95	4·95	5·08	3·20	3·26	1·90	1·97	3·37	5·75
Torque lb. ft.	44,700	41,300	42,100	43,500	35,300	35,200	34,700	35,900	23,800	24,700	15,400	15,700	25,800	39,800
Torque, mean of means or mean for runs lb. ft.	42,300				35,110				24,250		15,550		25,800	39,800

TABLE XXXIVB.—*Fuel Consumption (Starboard Main Engine only); and Torque from Characteristic Diagram.*

Run Number.	Fuel per Minute (Observed).	Fuel per Minute (Corrected as above).	Torque
	Lb.	Lb.	Lb. Ft.
13	2·97	2·91	21,500
14	5·62	5·35	36,200

The average results of the trials are recorded in Table XXXIII.

used during the trials of the port engine ashore were employed. These were interposed in the supply-pipe respectively to the port main engine and the port generator engine. The observations of fuel consumption recorded in Table XXXIVA were, therefore, obtained as follows:—For the measured mile runs only fuel passing to the port main engine and fuel passing to the port generator engine were measured by observation of the fall of level in the calibrated measuring tanks. Observations of the fuel used in the generator engine, in conjunction with the electrical output of the generator as measured at the switchboard, give a consumption of 0·71 lb. of fuel per kw.-hour, a quantity which has been used to obtain the net consumption of the main engines from the observed consumption for all purposes.

For the fuel-consumption trials the fuel passing to both port and starboard engines and to the electric generator engines in use—that is, fuel for all purposes—was measured by the fall of level in the service tanks, by pneumercator gauge. To obtain the net fuel used by the two main engines together, the estimated fuel consumption of the generator engines (being the total electrical output of the generators as measured at the switchboard multiplied by 0·71 lb. per kilowatt-hour) is deducted from the fuel required for all purposes The results are given in Table XXXIII.

The quantity of fuel passing to the port and starboard main engine for each trial (Run Nos. 13 and 14) has been determined by dividing the fuel passing to both main engines together, in the ratio of the indicated horse-power developed by each engine. These results are shown in Tables XXXIVA and XXXIVB.

For both the measured mile and the consumption trials the fuel used per minute has been plotted to a base of indicated horse-power (Fig. 30). In Tables XXXIVA and XXXIVB the observed rates of fuel consumption are shown, as well as those corrected to agree with the fair curve of Fig. 30 and for difference of calorific value.* The corrected consumptions only have been used to derive the engine torques from the Characteristic Diagram.

Indicator cards were taken from the combustion and steam sides of both engines on every run. The mean indicated pressures as determined from the cards taken from the steam side have been multiplied by the factor 0·9193 for reference to the area of the combustion cylinders. Mean indicated pressures for combustion and for steam referred to combustion area were recorded for port and starboard engines. The indicated horse-powers developed by both engines are recorded in Table XXXVII.

The torques read off the Characteristic Diagram (Fig. 21), using the fuel consumption and the engine speed only, are recorded in Table XXXIVA for the port engine for all runs, and in Table XXXIVB for the starboard engine for Run Nos. 13 and 14 only. Using the mechanical efficiency—M.I.P. curve (Fig. 18) deduced from the trials ashore of the port engine, values for the torques delivered by both port and starboard engines are derived from the mean indicated pressures obtained at sea. These torques are given in Table XXXVII.

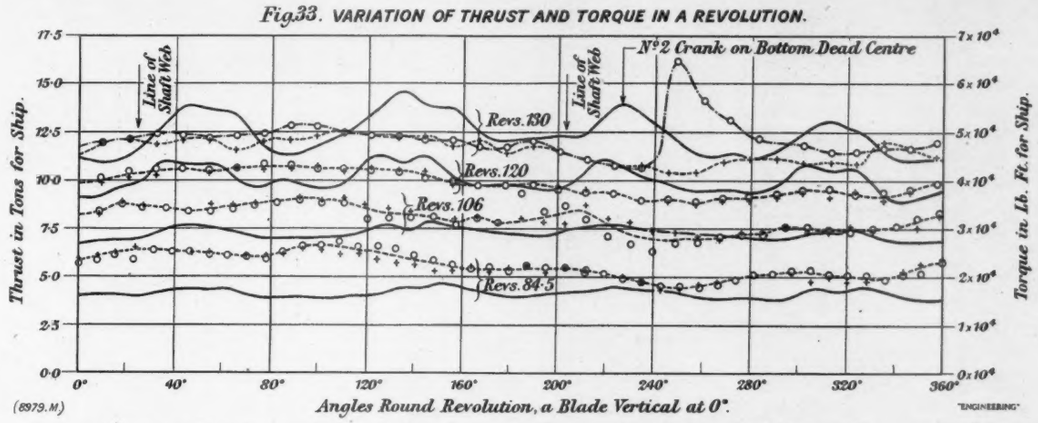
Similarly, the use of torque—M.I.P. curve (Fig. 19) also drawn for the shore trials, directly gives the torques delivered by the engines, and should agree with those obtained by the method of the preceding paragraph.

The torsional displacements were only indicated on the port propeller shaft, on which a Moullin torsionmeter was mounted. From the continuous photographic records taken with this instrument the mean torques and percentage fluctuations of torque have been obtained. Characteristic curves which show the variation of torque throughout a revolution are reproduced in Fig. 33; two consecutive revolutions are given in order to show the extent to which the peculiarities of the curves are repeated. At the angular position, marked 260 deg., in the runs of 132·9 r.p.m. only (Runs 1 to 4) a peak occurred at every fourth revolution, and, accordingly, is shown as a specific feature of the torque diagram. This peak did not occur in the runs at any other speed, nor on the long run at the same nominal revolutions (Run 14), which was carried out on the next day. The mean values of the torque and the percentage fluctuations are recorded in Table XXXVIII.

The propeller thrust was measured on the port shaft only. The ship is fitted with Michell measuring-type thrust-blocks, which permit of measurements being made without further adaptation. Two continuous records of the pressure in the system were taken over short periods during each run on the measured mile and at half-hour intervals on the two consumption runs. The apparatus used for recording the pressures was supplied by the William Froude National tank, and was connected to the oil-pressure system of the port thrust-block. One record was obtained by the elongation of a spiral spring actuated by a plunger in a small cylinder connected with the pressure system behind the rams. The pressure was automatically recorded together with time in half-seconds, and a contact mark when a particular propeller blade was vertical, on a strip of paper moved by clockwork. Another record was obtained on the same strip of paper by using a special gauge made for the purpose by the Budenberg Gauge Company; the movements of this gauge were enlarged and were recorded at the same time as the previous indications.

Typical curves of the variation of thrust throughout a revolution are shown in Fig. 33. As the records of torque were taken at practically the same time as those of the thrust, the typical curves of torque obtained from the torsionmeter records are shown on the same figure. The latter curves are arranged to have about the same oridinate value as the corresponding thrust record. It will be noticed that at

Fig. 33. VARIATION OF THRUST AND TORQUE IN A REVOLUTION.



——— Thrust on port shaft at revolutions noted. — . — Torque on port shaft at revolutions noted. - - - - - During two consecutive revolutions. The marked torque at 230 deg. at 130 r.p.m. was occasionally followed by a similar depression. The revolutions are taken from the thrust record, and differ a little from the mean taken over the mile run.

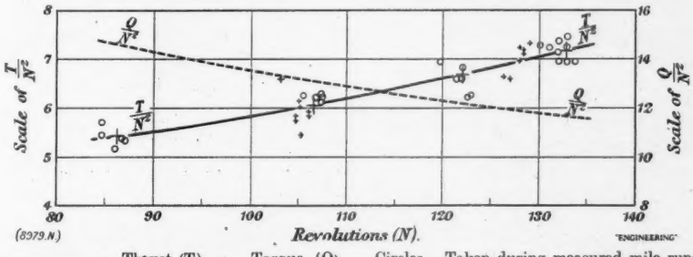


Fig. 34.—Curves of $\frac{\text{Thrust (T)}}{(\text{Revs.})^2\,(\text{N})}$ and $\frac{\text{Torque (Q)}}{(\text{Revs.})^2\,(\text{N})}$ to base of revolutions.

T in tons for 1 screw
N in units of 100 r.p.m. } Port shaft.
Q in ton-ft.

Circles.—Taken during measured mile runs, April 2, 1924.

Small Crosses.—Taken during long runs of April 3, 1924.

Large Crosses.—Mean of measured mile runs using revolutions per minute on port shaft.

TABLE XXXV.—*Analyses of Fuel Oil.*

Run Number:	1 to 12		13 and 14	
Trade description of fuel	Anglo-American Diesel Oil.			
Calorific value (gross) B.Th.U. per lb.	19,200		19,240	
Specific gravity at (see Fig. 32) 86 deg. F.	0·891			
Specific gravity at (see Fig. 32) 104 deg. F.	0·885			
Specific gravity at (see Fig. 32) 122 deg. F.	0·878			
Closed flash point, deg. F.	177		182	
Burning point, deg. F.	181		189	
Viscosity (by Redwood viscometer)—No. 1, seconds at 32 deg. F.	8·7		8·7	
No. 2 " " 70 deg. F.	43·1		43·3	
No. 2 " " 150 deg. F.	30·4		30·4	
No. 2 " " 200 deg. F.	28·4		27·7	
Cold test	Slightly less fluid at — 14 deg. F. than at 59 deg. F.		Slightly less fluid at — 14 deg. F. than previous sample.	
Engler distillation—Temperature of first drop, deg. C.	152–158 (Thermometer rising rapidly.)		140	
	Per Cent.	Sp. Gr.	Per Cent.	Sp. Gr.
Fraction from 0–150 deg. C.	Nil	—	Nil	—
" " 150–200 deg. C.	0·60	—	0·30	—
" " 200–250 deg. C.	20·50	0·854	25·50	0·841
" " 250–300 deg. C.	54·85	0·872	51·60	0·891
" " 300–350 deg. C.	18·38	0·901	18·05	0·950
" " residue	3·87	—	3·83	—
" " loss	1·80	—	0·72	—
Water content	Nil		Nil	
Ultimate analysis—Carbon Per cent.	87·04		86·97	
Hydrogen "	12·63		12·38	
Nitrogen "	0·05		0·05	
Sulphur "	0·28		0·17	
Oxygen and errors "	Nil		0·43	
Impurities	Very little sediment with some larger specks. Light coloured.		Similar to previous sample but less sediment.	
Carbon residue and free carbon Per cent.	0·40		0·38	
Ash "	0·001		0·010	
Soft asphaltum "	0·30		0·26	
Hard asphaltum "	0·02		0·07	

* Of the fuel used during the trials at sea and that used during the trials on the test bed ashore, in order that the Characteristic Diagram (Fig. 21, page 400 *ante*) can be used directly.

high speeds the thrust records show more variation than do those of torque; this is due presumably to wake effect, as there are no well marked corresponding fluctuations in the torque curves which can be associated with the thrust variation.

The thrusts measured on the port shaft during the trials are shown as values of thrust/revolutions², or $\left(\frac{T}{N^2}\right)$ plotted to a base of revolutions per minute in Fig. 34. The ordinates shown have been derived from the mean thrust and the revolutions observed at the time of taking the thrust record on a given run and the base to which these values are plotted is the mean revolution per minute over the run. The bossings add 4 per cent. to the model resistance or 2 per cent. to the ship, and a total of 10 per cent. has been taken to cover all appendages and wind resistance.

The total thrust for the ship, which is given at the bottom of the table, has been obtained from that of the port shaft, by assuming the wake and efficiency of both propellers to be identical. In this case the thrust on the starboard shaft is given by:—

$$T_{port} \times \frac{R.P.M._s}{R.P.M._p} \times \frac{Torque_s}{Torque_p}$$

The estimated thrusts are obtained by assuming the augment of resistance to be the same for ship and

TABLE XXXVII.—INDICATED HORSE-POWER (BOTH MAIN ENGINES).

Mechanical Efficiency Corresponding to M.I.P. from Fig. 18.

"Brake" Horse Power = I.H.P. × Mechanical Efficiency Obtained at Shore Trials.

$$\text{Corresponding Torque} = \frac{\text{"Brake" Horse-Power} \times 33{,}000}{2\pi \times \text{R.P.M.}}.$$

Run Number:	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Port engine—														
I.H.P. combustion ..	1,209	1,100	1,120	1,177	885	891	883	915	571	583	348	360	607	1,028
,, steam	59	60	61	60	56	37	46	39	25	26	9	8	23	55
Total indicated horse-power	1,268	1,160	1,181	1,237	941	928	929	954	596	609	357	368	630	1,083
Mechanical efficiency, per cent.	88·9	88·3	88·3	88·8	86·9	86·8	86·7	87·0	81·1	81·4	69·6	70·3	82·4	87·9
"Brake" horse-power ..	1,127	1,023	1,042	1,008	817	806	805	830	483	496	248	259	513	953
Corresponding torque, lb.-ft.	44,200	40,700	41,100	42,900	34,800	34,900	34,500	35,600	23,700	24,500	15,300	15,600	25,500	39,000
Torque, mean of means for runs, lb.-ft.			41,560				34,820			24,100		15,450	25,500	39,000
Starboard engine—														
I.H.P. combustion ..	1,053	1,041	1,048	990	770	787	795	788	489	510	292	307	523	962
,, steam	42	42	47	44	47	42	40	38	25	26	5	3	19	41
Total indicated horse-power	1,095	1,083	1,095	1,034	817	829	835	826	514	536	297	310	542	1,003
Mechanical efficiency, per cent.	87·8	87·7	87·9	86·8	84·8	85·1	85·0	84·9	77·0	78·0	58·2	60·3	78·5	87·0
"Brake" horse-power ..	962	950	963	899	693	705	710	701	396	418	173	187	425	873
Corresponding torque, lb.-ft.	38,100	37,800	38,400	35,300	29,700	30,600	30,600	30,300	19,800	20,900	10,900	11,600	21,200	35,700
Torque, mean of means for runs, lb.-ft.			37,750				30,450			20,350		11,250	21,200	35,700

TABLE XXXVIII.—DEDUCTIONS FROM THRUST AND TORSIONMETER OBSERVATIONS.

(The Observations were made on the Port Shaft only.)

Run Number:	1 to 4	5 to 8	9 and 10	11 and 12	13	14
Mean speed (V), knots	12·25	11·34	10·00	8·02	10·0	12·0
Mean R.P.M. (N)	132·9	122·1	106·5	86·1	105·6	128·4
$\frac{V \times 101{\cdot}3}{N \times \text{pitch}}$, from trial	0·957	0·965	0·875	0·968	0·973	0·968
Thrust (T) .. .. lb.	28,500	22,400	15,470	8,980	14,960	25,700
T/N^2	1·61	1·50	1·363	1,209	1·34	1·56
Steady variation of thrust from mean value, per cent.	± 12·5	± 9·5	± 6·5	± 8·5	± 7·0	± 10·0
Steady variation of torque from mean value, per cent.	+ 12·0 / − 11·6	+ 9·7 / − 9·4	+11·1 / −16·6	+19·2 / − 17·4	± 10·6	± 9·5
Indicated horse-power (total)	2,274	1,763	1,130	665	1,172	2,086
E.H.P. (naked), from model tests	1,220	925	605	300	605	1,140
E.H.P./I.H.P. (total)	0·537	0·524	0·537	0·450	0·516	0·547
I.H.P./V^3	1·24	1·21	1·13	1·29	1·17	1·21
Torque (lb.-ft.) by—						
(*a*) i. Torsionmeter (port shaft)	46,100	40,750	32,800	24,200	29,500	41,500
ii. Torsionmeter (both shafts), estimated*	87,950	76,350	60,500	41,800	54,000	79,500
(*b*) Model E.H.P. + 10 per cent., using model propulsive coefficient and r.p.m. for runs	91,200	77,400	58,800	36,500	59,300	90,000
(*c*) Indicated horse-power and mechanical efficiency corresponding thereto. (Table XXXVI)	79,310	65,270	44,450	26,700	46,700	74,700
Total thrust estimated† from that measured on the port shaft	54,300	41,850	28,300	15,370	27,300	49,200
Thrust from E.H.P. + 10 per cent. with allowance for model augment of resistance	—	34,450	24,900	15,920	24,900	39,200

* Torque on starboard shaft has been taken to be:

$$= \text{Torque on port shaft} \times \frac{\text{torque by indicator cards from starboard engine}}{\text{torque by indicator cards from port engine}}.$$

† $\text{Thrust}_s = \text{Thrust}_{port} \times \left\{\frac{\text{r.p.m.}_s \times \text{torque}_s}{\text{r.p.m.}_p \times \text{torque}_p}\right\}$.

variation between the points obtained from runs at any one nominal speed are assignable to: experimental errors, cyclical variations in the engine speed, and the use of helm. In the same figure are shown, for comparison, the corresponding values of torque/revolutions² or $\left(\frac{Q}{N^2}\right)$.

A model of the ship was made and tested in the "William Froude" National Tank. The tests were made after the trials at sea, and the draughts of the model were made to correspond exactly to the trial conditions. The model was naked, i.e., without bossings or other appendages. The E.H.P. values obtained are given in Table XXXVIII. As the vessel was freshly painted and was out of dock only a few days before the trials, the results obtained with the model should apply to the ship with only a small addition for appendages. for model with the propeller developing the same slip, and using this augment in association with a delivered power equal to the E.H.P. plus 10 per cent.

A manœuvring trial was carried out following the completion of the measured mile runs on April 2, on both port and starboard engines, the object being to determine the rapidity with which the engines could be manœuvred and the ability of the steam-raising plant (*i.e.*, the main regenerators fired directly as boilers) to meet the demands made upon it. The auxiliary burners under the regenerators were therefore in operation continuously throughout the test. The orders were given from the bridge and the time intervals between the receipt of an order in the engine room and the attainment of the given engine speed is recorded for each order in Table XXXIX. The column headed "R.P.M." represents the speed of the engine as prearranged to agree with the titling on the telegraph. The Elliott electrical tachometer on each engine was relied upon as the indication that a particular speed had been achieved. Immediately an order had been carried out a signal was sent from the engine room to the bridge. In the case of reversals at full speed (Order Nos. 10 and 11) a period of 1 minute was allowed after full speed had been attained in order that the ship should gather way and to ensure as far as possible that the next manœuvre should be made under average working conditions. In all other cases no such period was allowed. The tests in this section as well as those next to be described, were carried out by the engineers of the ship.

TABLE XXXIX.—*Manœuvring Trial.*

Order on Telegraph.			R.P.M. on Tacho-meter.	Time to carry out the Manœuvre.		Pressure in Steam Drums.
No.	Direction.	Speed.		Port Engine.	Star-board Engine.	
				Secs.	Secs.	Lb. per sq. in.
1	Stop ..	—	—	20	13	130
2	Ahead ..	Dead / Slow / Half	60	14	14	
3	Astern ..		80	37	20	
4	Stop ..	—	—	12	18	
5	Ahead ..	Slow	85	24	18	
6	Astern ..	Half	80	22	14	
7	Ahead ..	,,	105	35	35	
8	Astern ..	Full	100	19	15	100
9	Stop ..	—	—	*	*	
10	Ahead ..	Full	120	22	13	
11	Astern ..	,,	100	22	15	
12	Ahead ..	,,	120	22	22	
13	Stop ..	—	—	10	10	100
14	Ahead ..	Slow	85	26	18	
15	Astern ..	,,	65	14	9	
16	Ahead ..	,,	85	14	11	
17	Astern ..	,,	65	14	12	
18	Ahead ..	,,	85	10	7	
19	Astern ..	,,	65	14	11	
20	Ahead ..	,,	85	11	8	
21	Astern ..	,,	65	12	11	
22	Ahead ..	,,	85	12	9	
23	Astern ..	,,	65	13	12	80
24	Ahead ..	,,	85	9	7	
25	Astern ..	,,	65	12	8	
26	Ahead ..	,,	85	10	9	70
27	Stop ..	—	—	—	—	

* Observation lost, unofficial observation 12 seconds for each engine.

A slow speed test was carried out, on both engines, on the completion of the manœuvring trial. The test was divided into two parts, namely:—

(1) With the combustion cylinders only in operation, the lowest speeds maintained on readings over a period of 5 minutes were:—

	R.P.M.
For port engine	57·6
For starboard engine	68·8

(2) With steam, only, operating in the four cylinders not compounded, being the "steam" position on the manœuvring dial, the speeds maintained are shown in the annexed table. The revolution per minute of each engine were gradually reduced as the ship gathered way. Compression on the combustion side was not released for the purposes of the test, which represents the normal mode by which continuous running at slow speed would be conducted at sea.

R.P.M. reckoned on Readings over the Final.	Port Engine.	Starboard Engine.
10 minutes	28·1	30·7
5 minutes	21·8	26·6

DANGERS OF ETHYL GASOLINE.—Ethyl gasoline is ordinary motor spirit to which about 0·04 per cent. of Tetraethyl lead and further 0·06 per cent. of a halogen carrier, such as ethylene debromide, are added in order to eliminate detonation or knock (hence the name anti-knock) and to make higher-compression ratios possible. Tetra-ethyl lead is poisonous like all lead compounds. From experiments conducted on behalf of the United States Bureau of Mines, by R. R. Sayers and A. C. Fieldner (Serial 2655) it would, however, appear that the exhaust from internal combustion motors burning ethyl gasoline is not dangerous to animals. Various animals of different species and sizes were exposed to the exhaust gases for months in boxes, which were ventilated, but left the test conditions severe. Most of the animals remained normal; the few that died did not show symptoms of lead poisoning. Men, inhaling the gas, exhaled again 75 per cent. of the very small percentage of the lead inhaled. There may be danger for the man who cleans the motor of the carbon deposited, and particularly for the man who has to deal with raw ethyl gasoline; these points are further to be investigated.